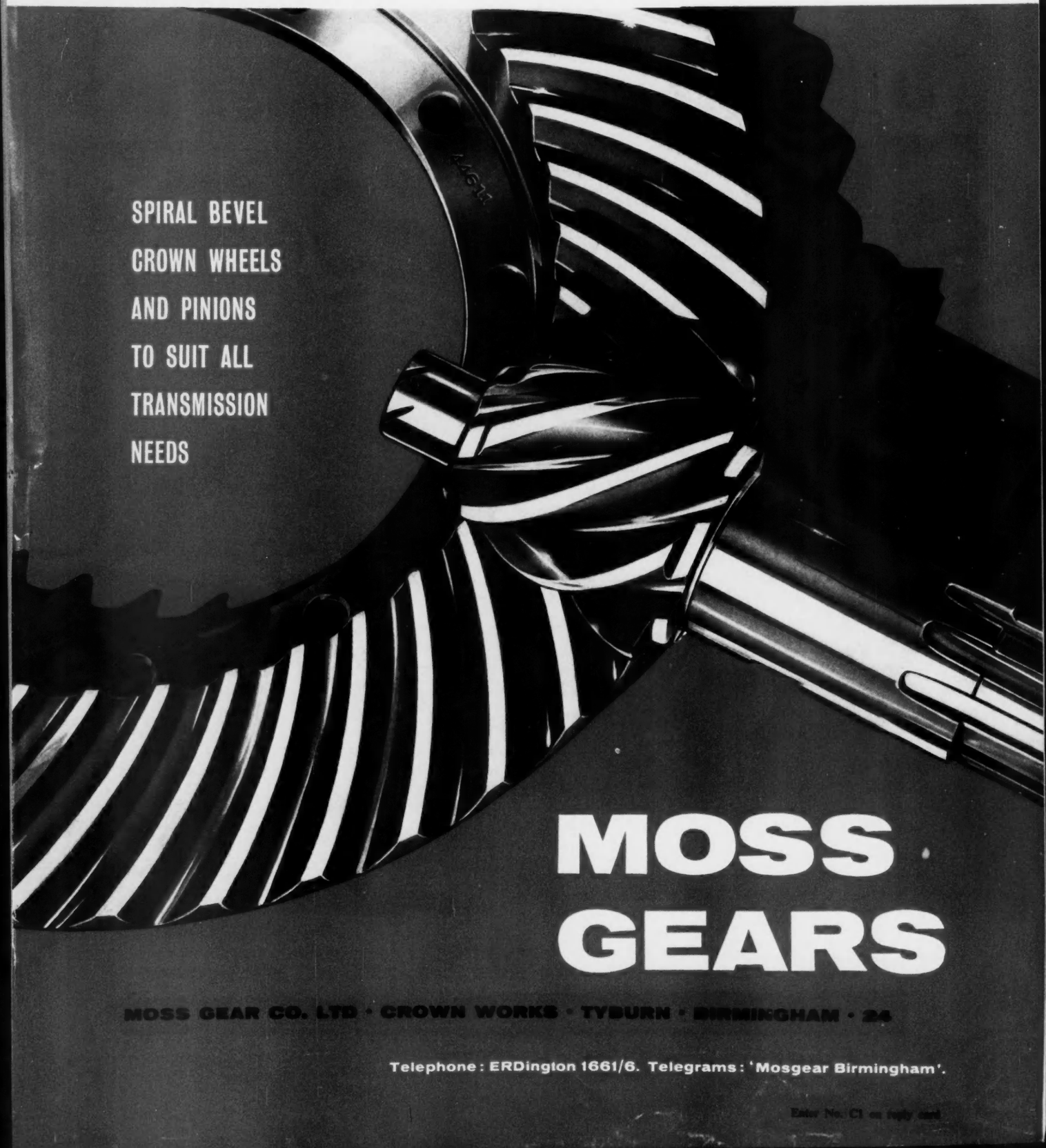
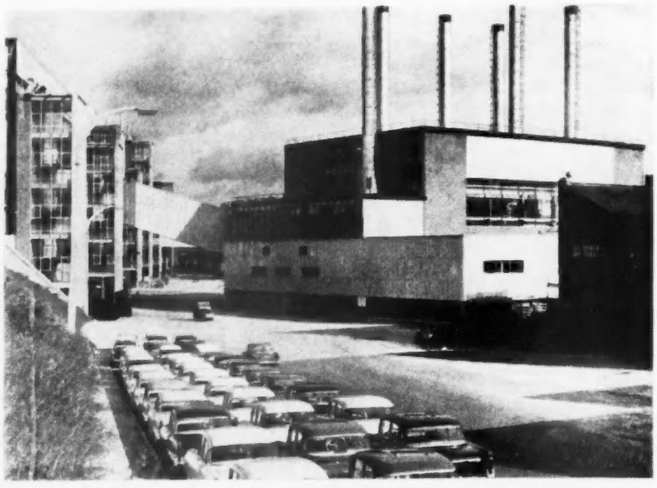
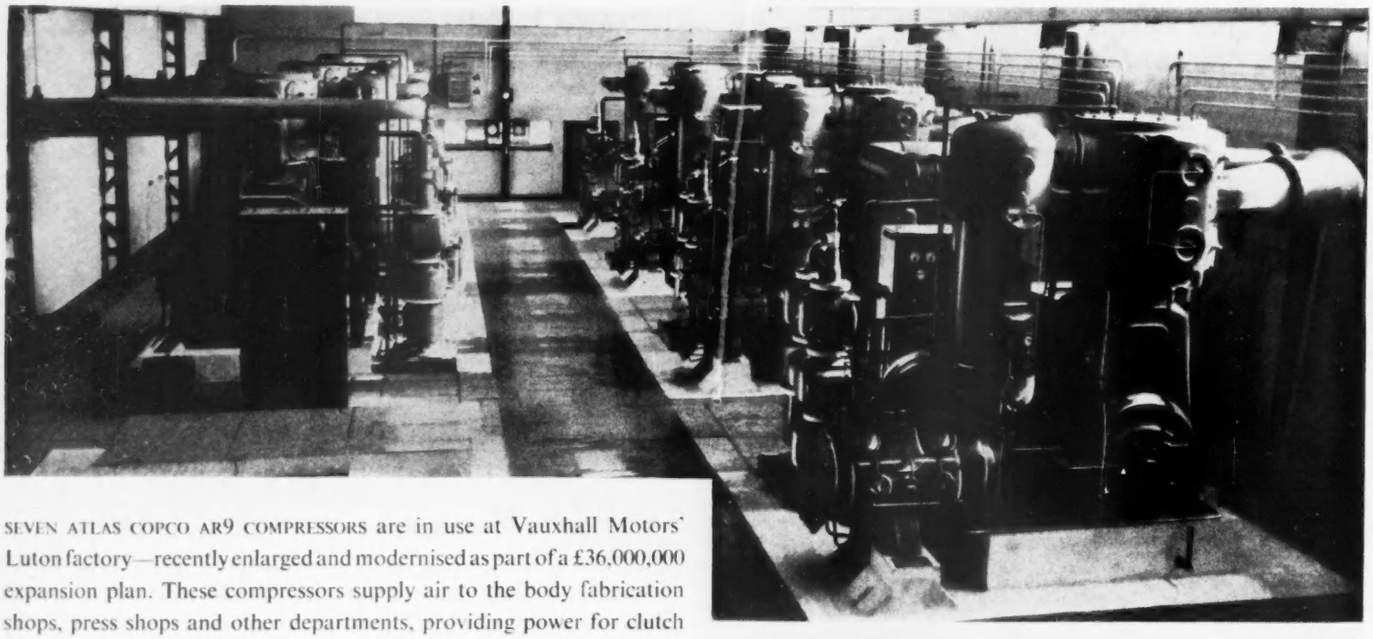
THE ENGINEER

DECEMBER 4, 1959 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS



Compressed Air at work in Vauxhall's Luton extension





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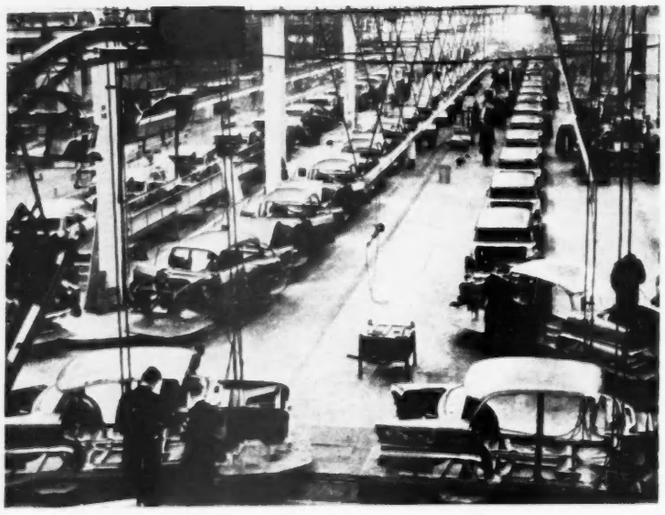

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THE ENGINEER

Established 1856

No. 5419 **DECEMBER 4, 1959** VOL. 208

EDITORIAL CONTENTS

Leading Articles	People and Power	723
	Estuarial Pollution	723
	The Navy's " New Look "	724
	Moral Dignity of Pleasure	725
Articles		
	100 Years Ago	725
	St. Lawrence River Development. No. X	726
	Dry Cooling Towers and Jet Condensing Plant	729
	Multi-System Electric Locomotives	731
	" Jason " Reactor for Research and Training	733
	Thermoelectric Cooling	734
	Symposium on Graphite for the " Dragon " Project	735
	Woolwich Arsenal and its Machines	736
G. A. Plummer	Wet Accumulators for Naval Steam Catapults	741
Robinson & Winder	Vacation Training of Undergraduate Engineers	743
	Main Line A.C. Locomotive	745
	Battery Vehicle Practice and Applications	747
	Human Problems in Marine Engineering	749
	Bridge over River Don at Doncaster	749
	Aluminium Columns for Streetlighting	749
	Light-Alloy Radio Towers	750
	Plastics Vessels for Chemical Plant	750
	Condenser Tube Preparation Machine	751
	Flow Meters	751
	Automatic Loading Equipment for a Lathe	751
	Multi-Channel Millivolt Recorder	751
	Heavy Plastics Protective Coatings	752
	Locomotives for Ship Canal Railway	752
Mainly Metallurgy		
	Sponsored Metallurgical Research	740
	The Phenomena Occurring in Steels During Quenching and Tempering	740
Continental Section		
	Optical Measurement of Principal Stresses	754
	Glass Fibre-Reinforced Vessels	755
	E.P.A. Film Information and Exchange Service	755
American Section		
	Large-Scale Nuclear Power Plants for Electric Utilities	756
	Tape Controlled Heliarc Spot Welding Machine	759
BOOK REVIEWS		738
NEWS AND NOTES	British Standards Institution	739
	Industrial and Labour Notes	753
	Personal and Business	760
	British Patent Specifications	761
	Forthcoming Engagements	762
	Advanced Engineering Courses	762

INDEX TO ADVERTISERS : PAGE 151 **CLASSIFIED ADVERTISEMENTS : PAGE 141**

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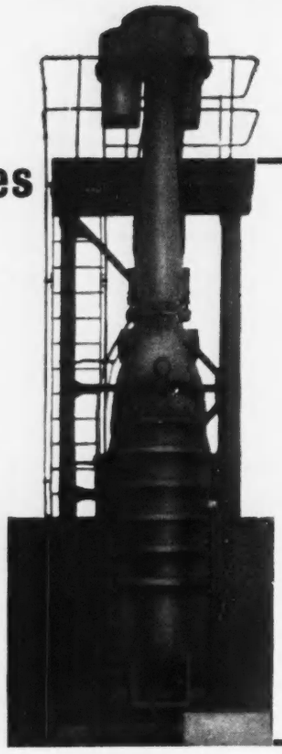

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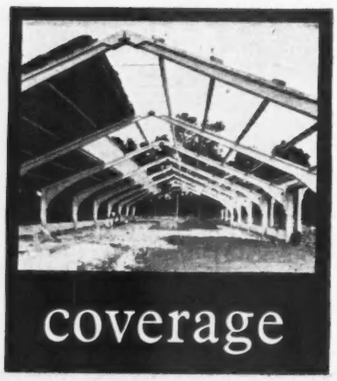

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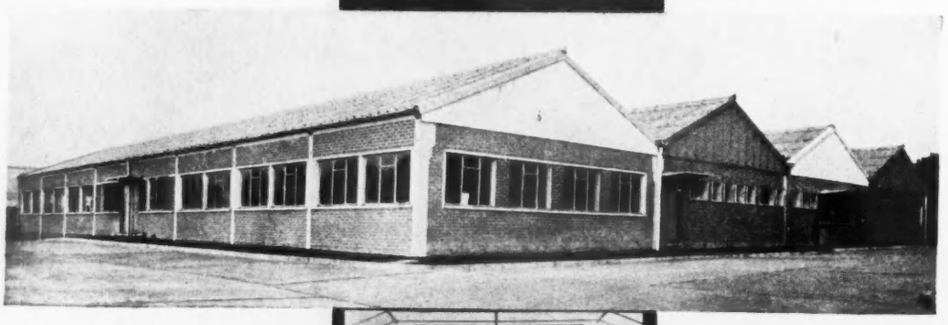

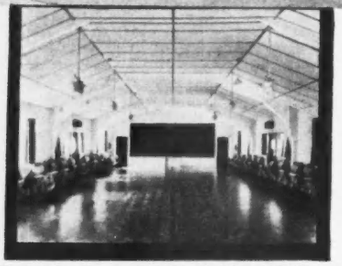

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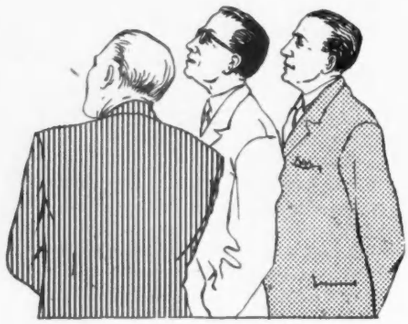

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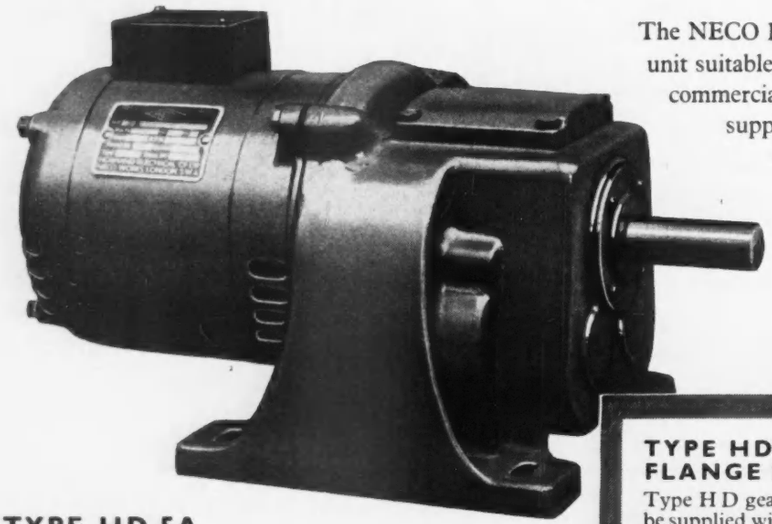

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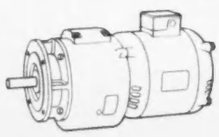

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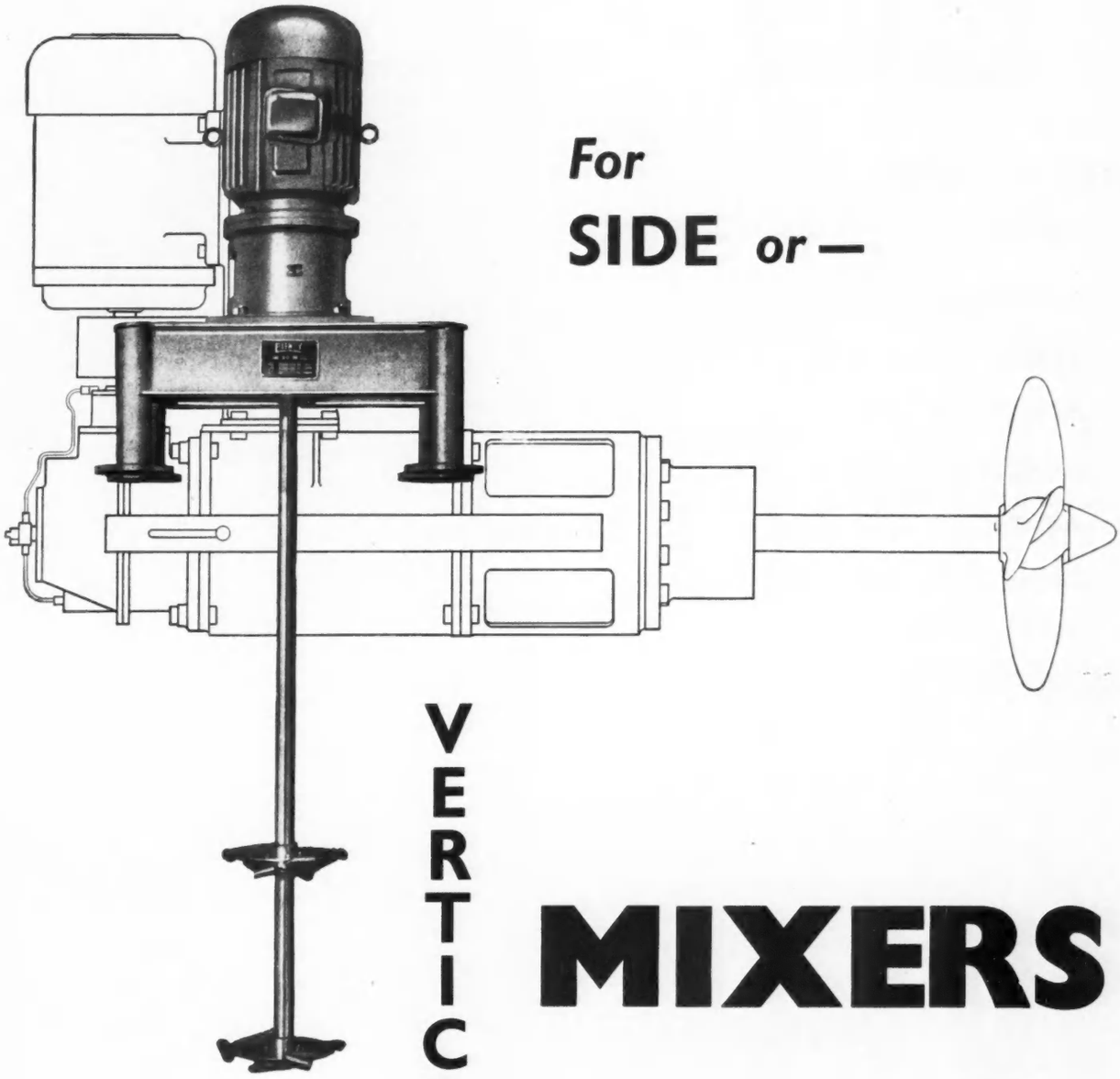

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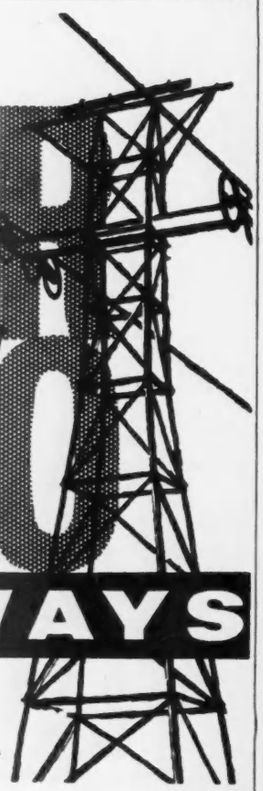

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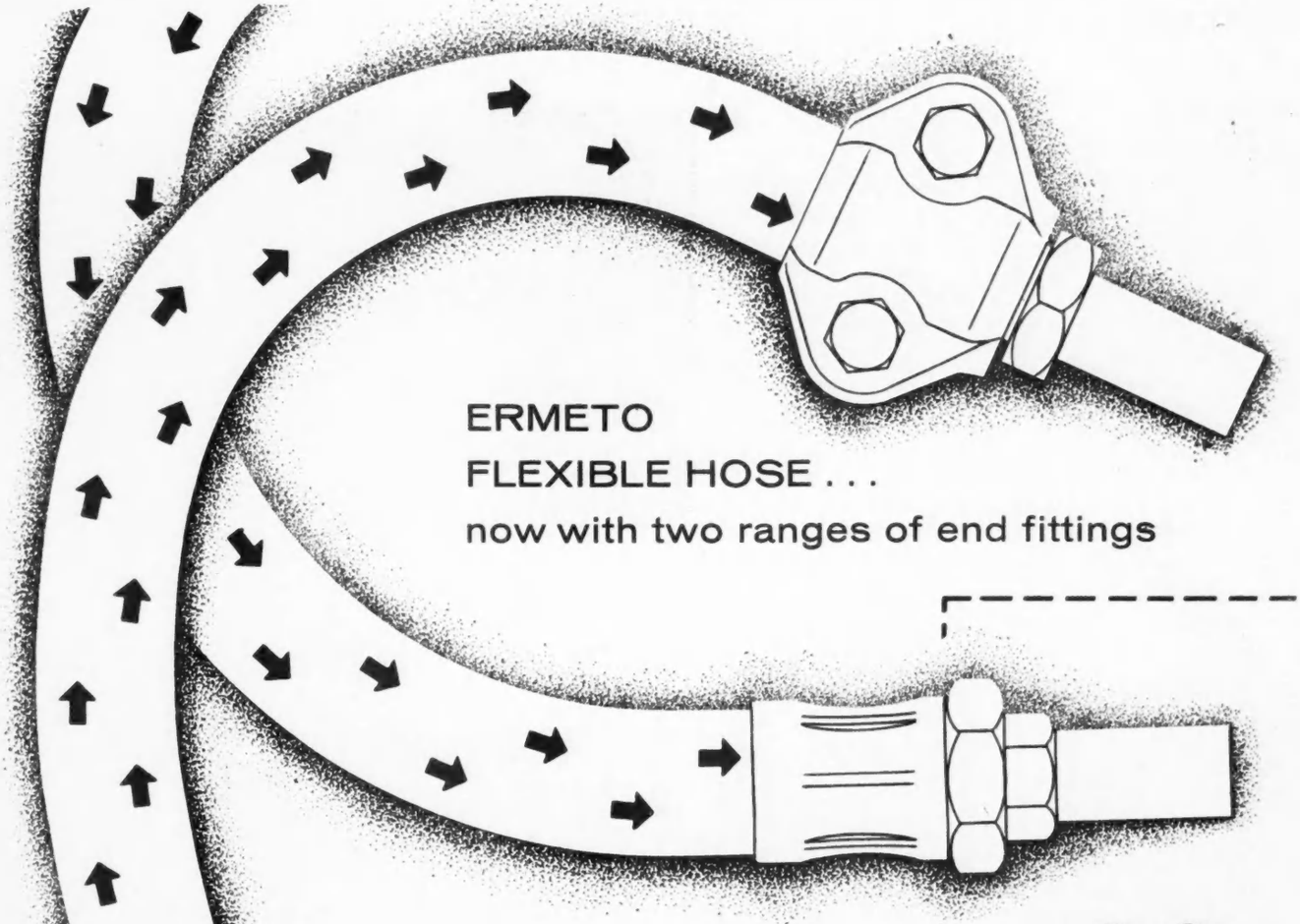

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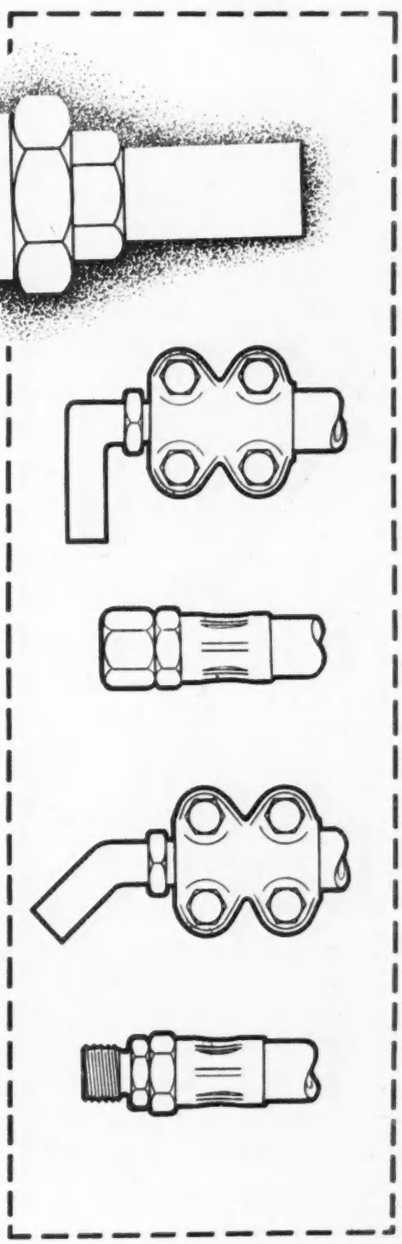

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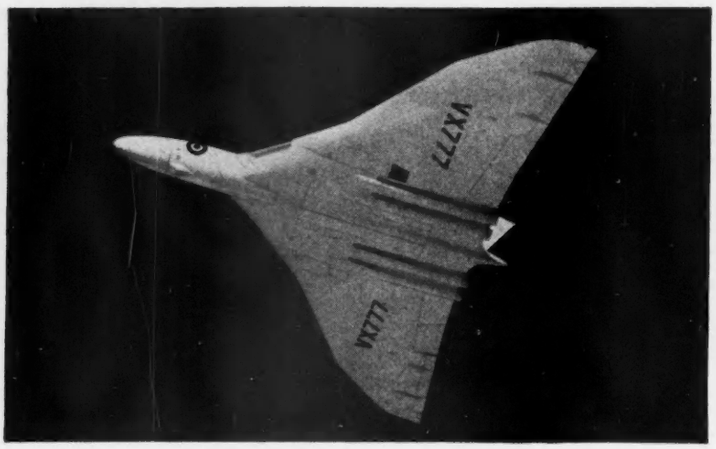

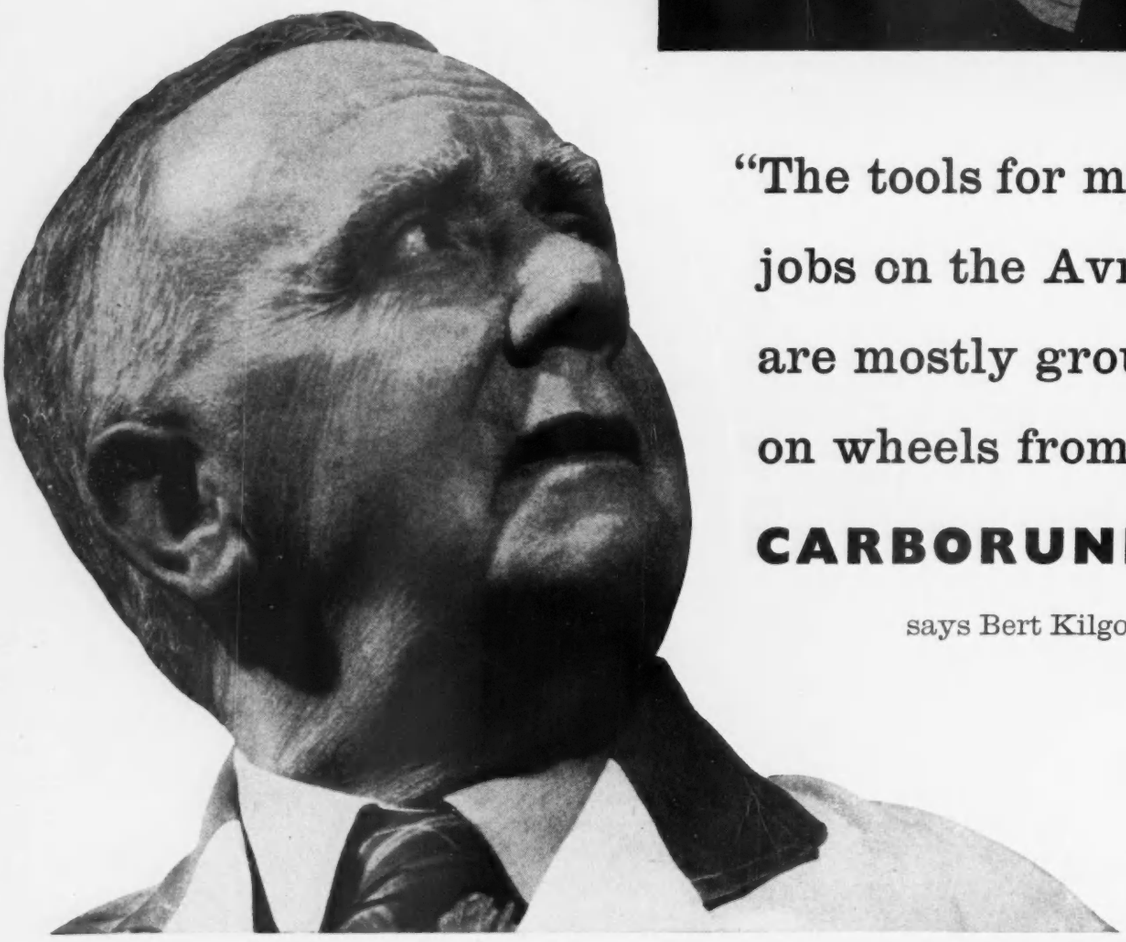

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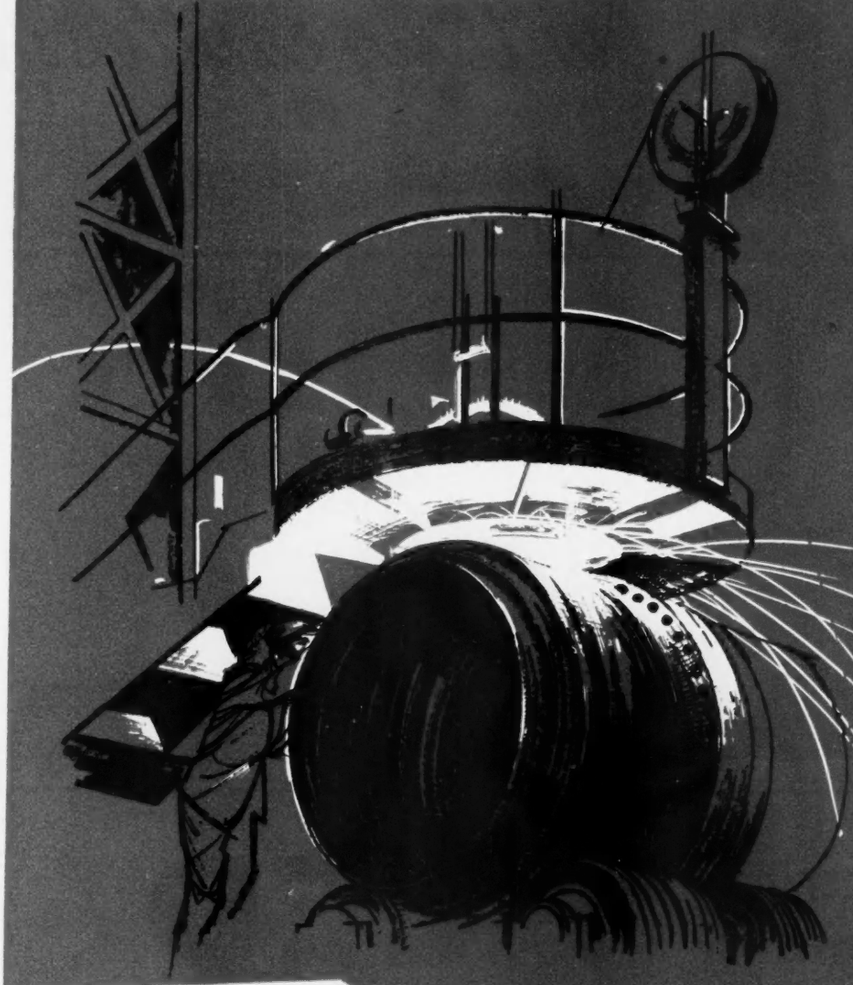

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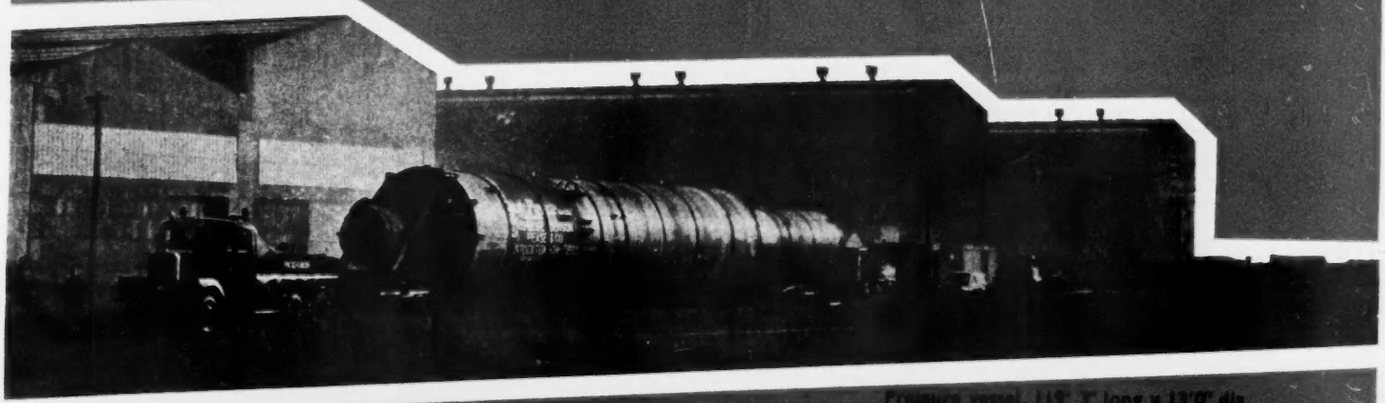

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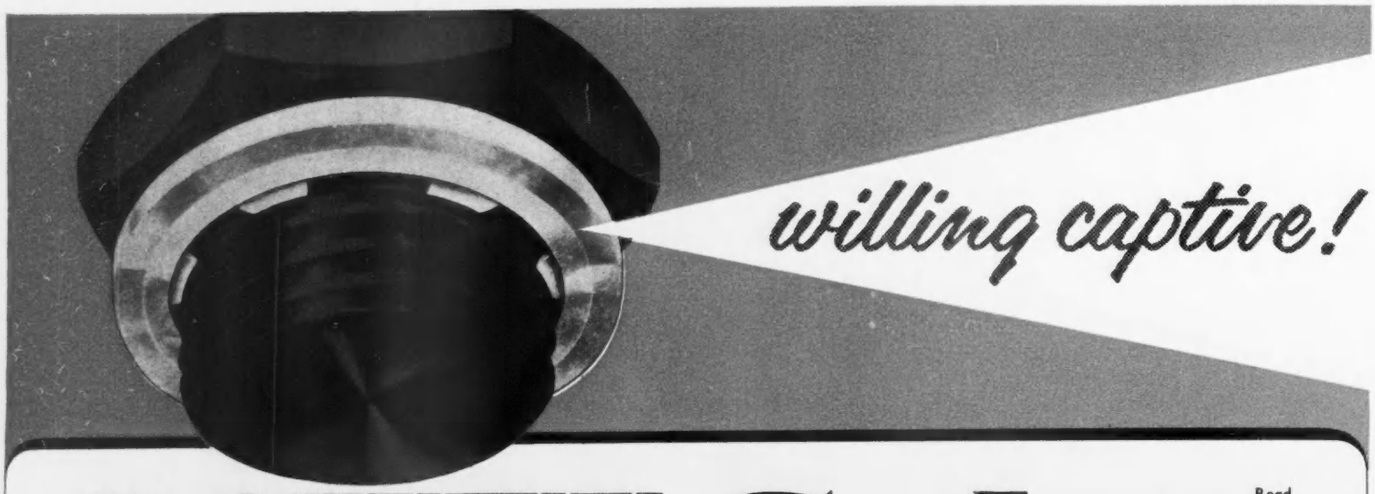

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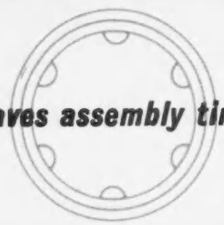

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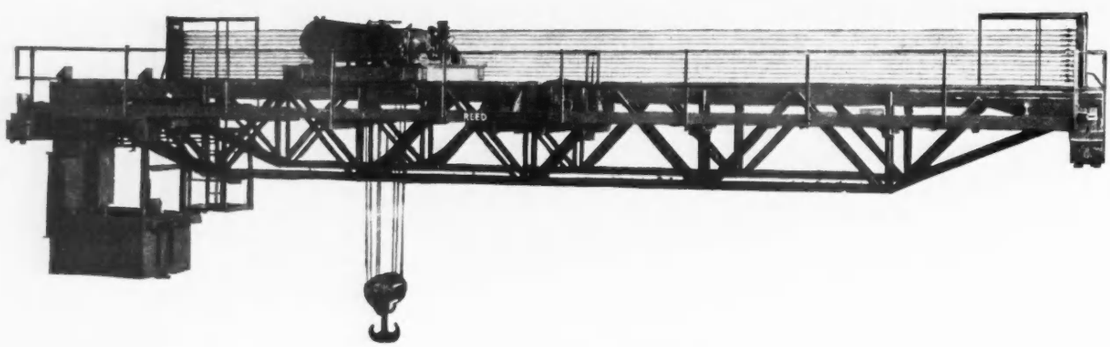

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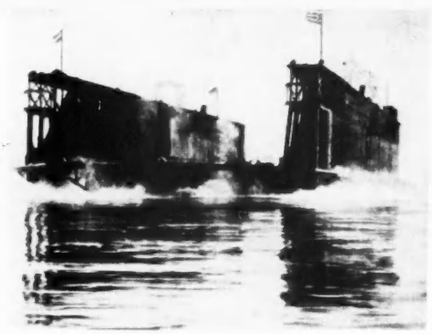

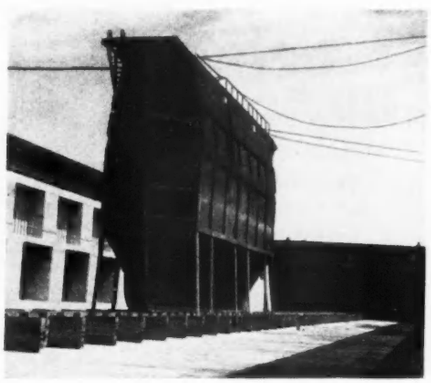

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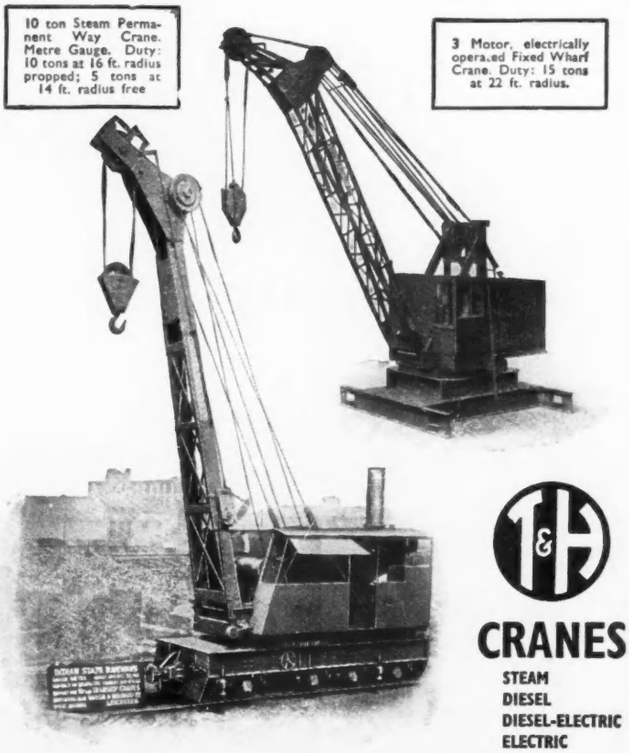

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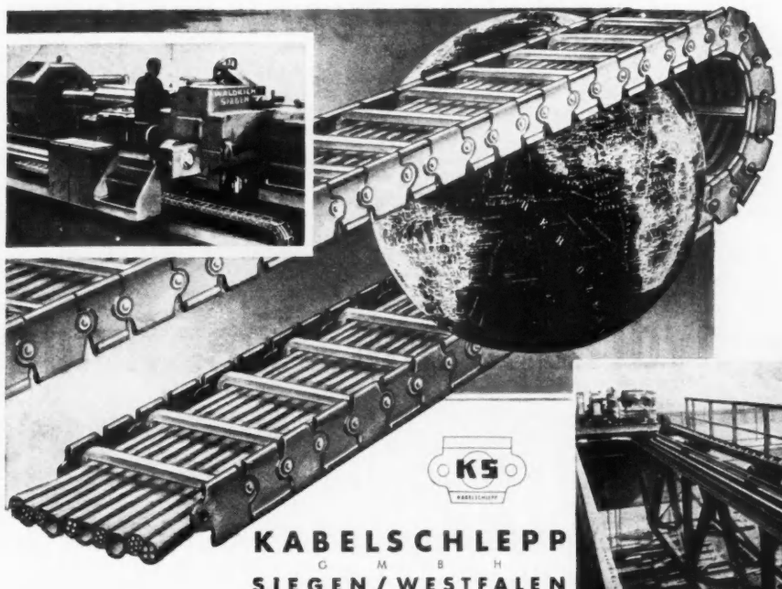

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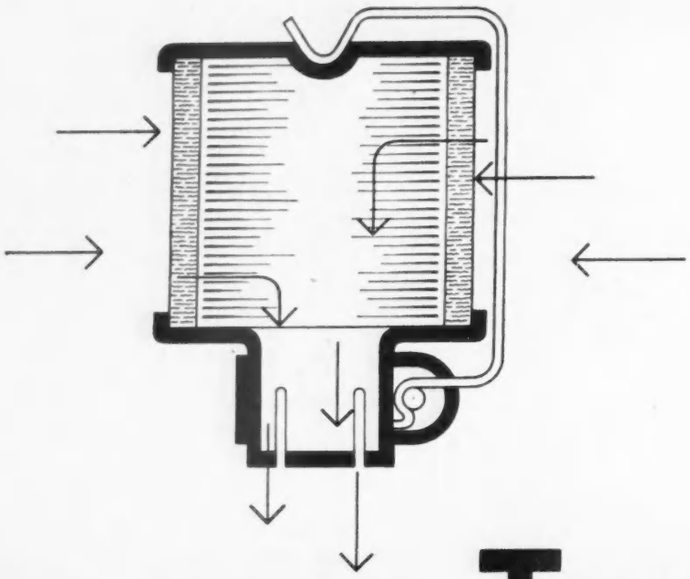

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Tecalemit ribbon elements filter to maximum purity

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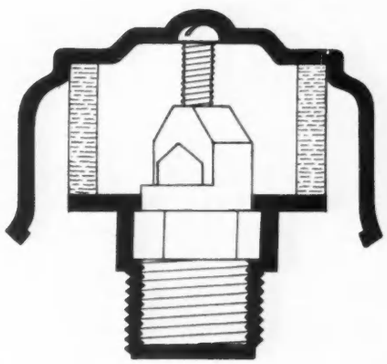

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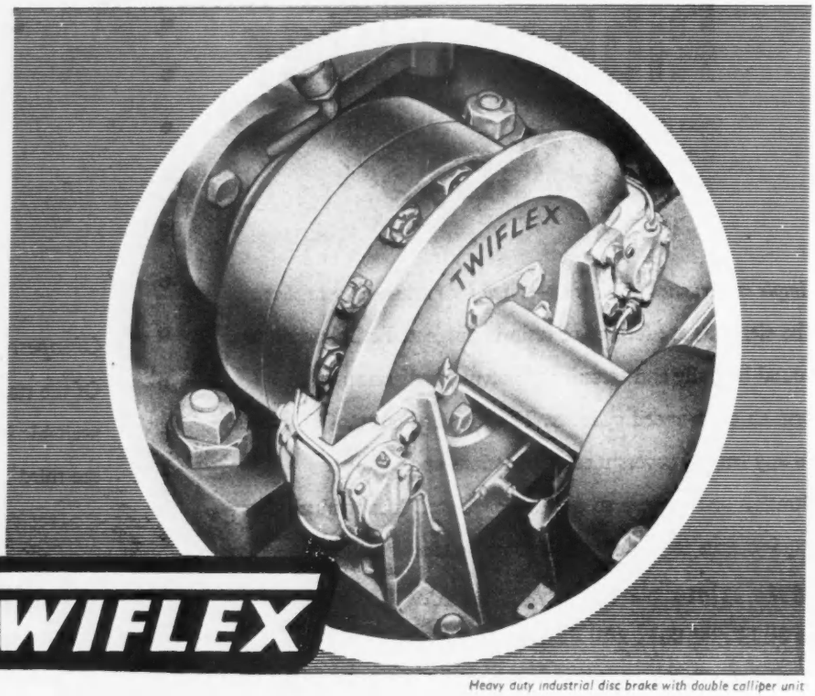

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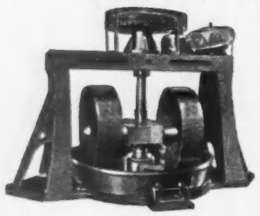

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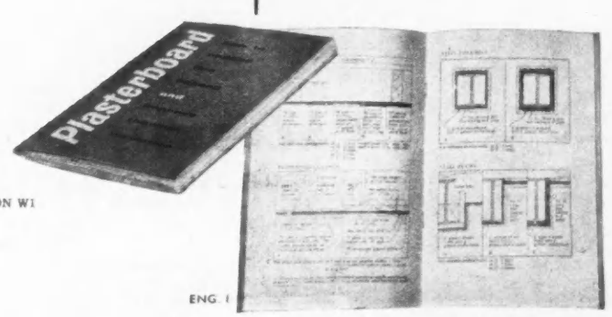

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ENG. I

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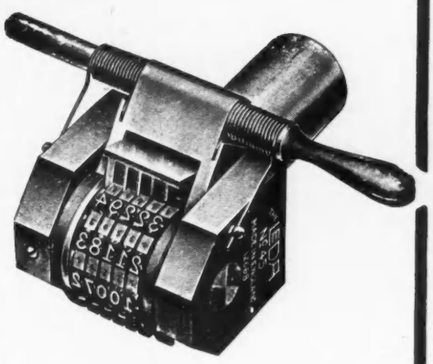

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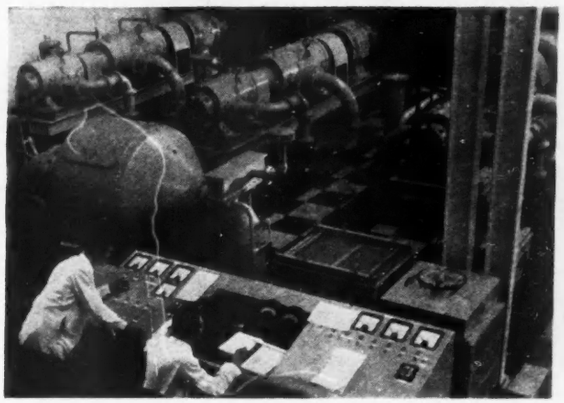

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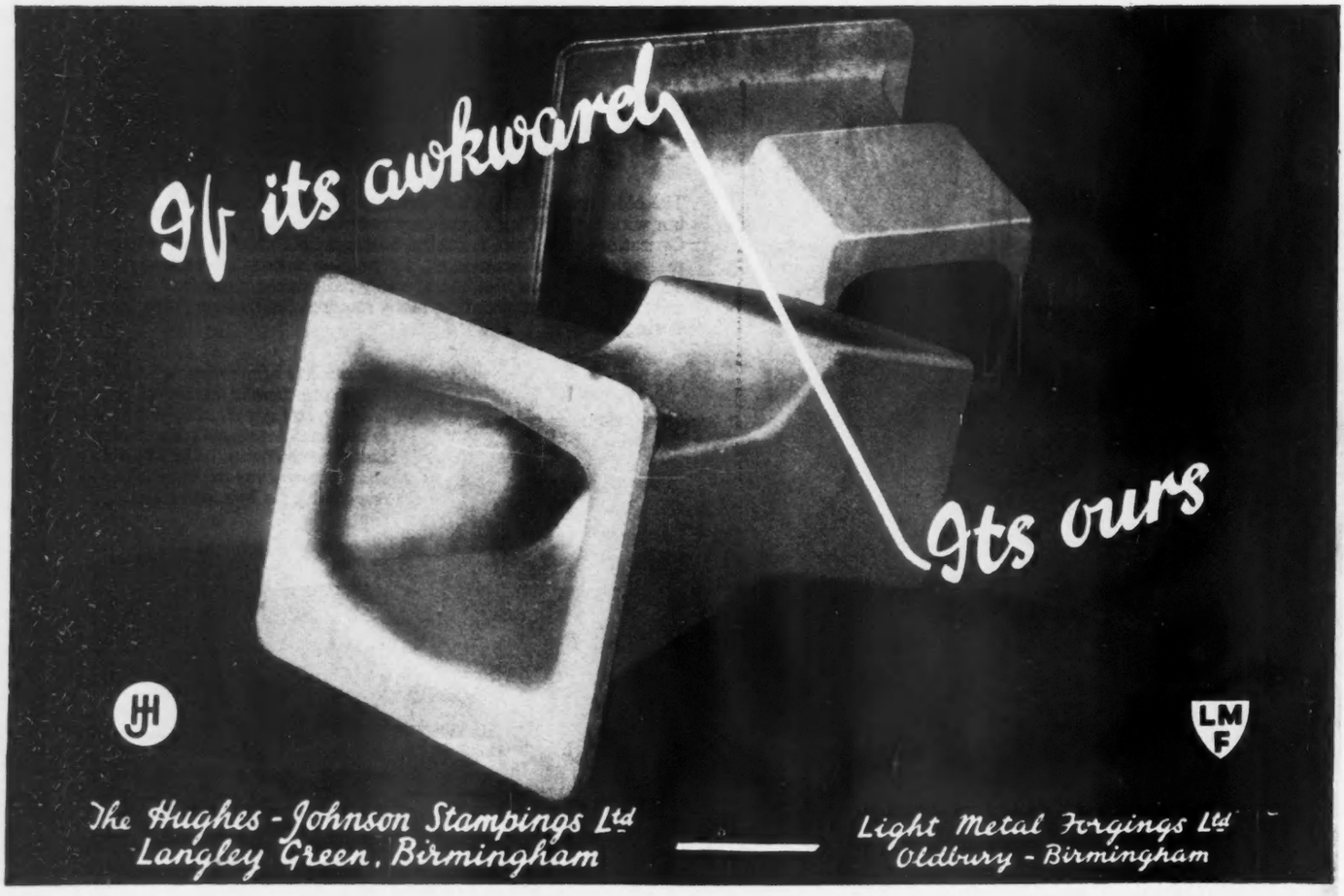

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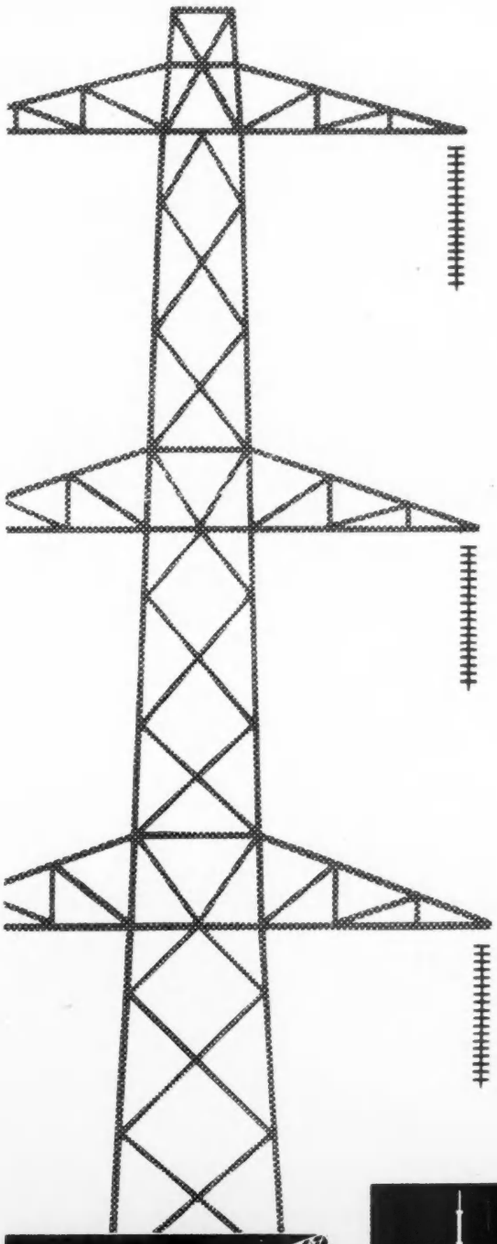

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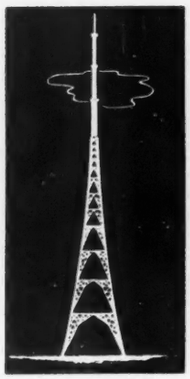

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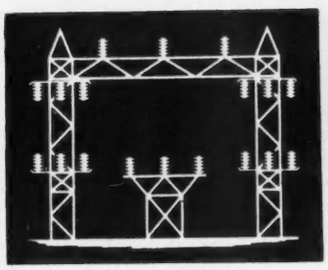

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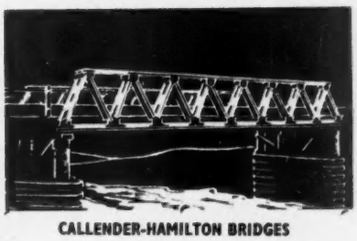

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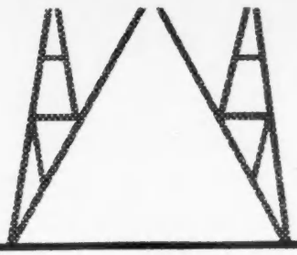

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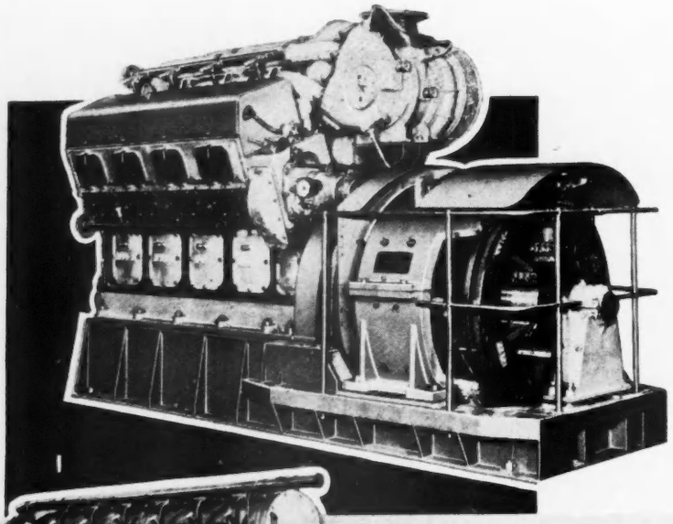

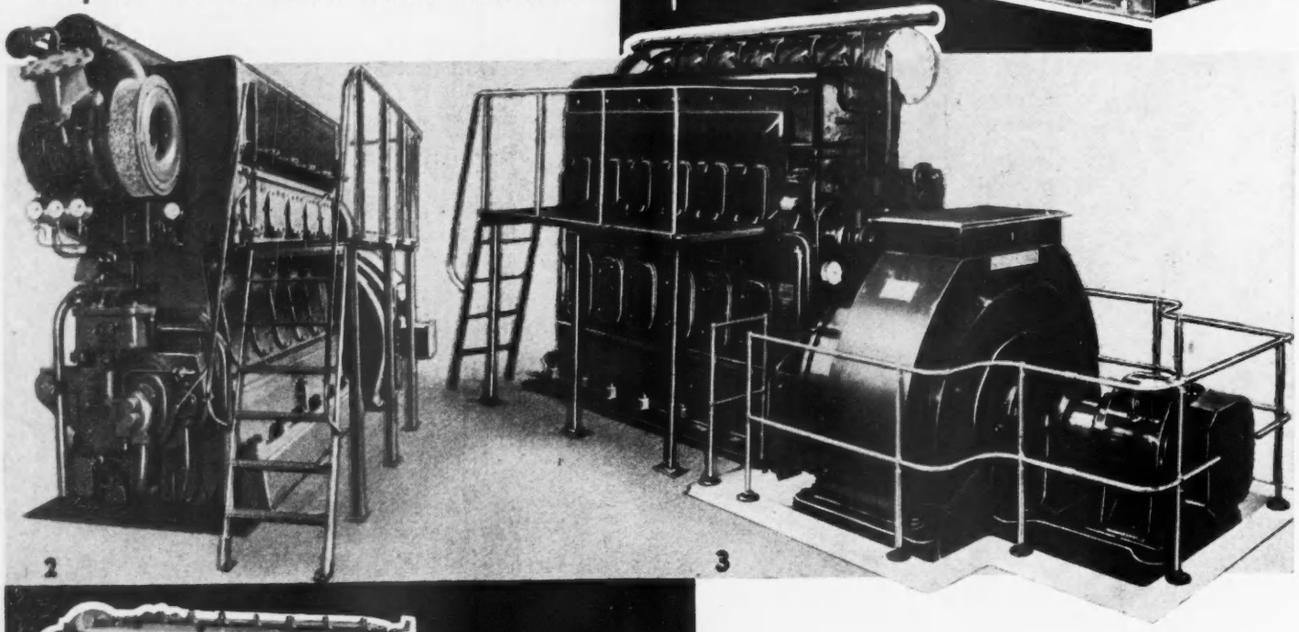

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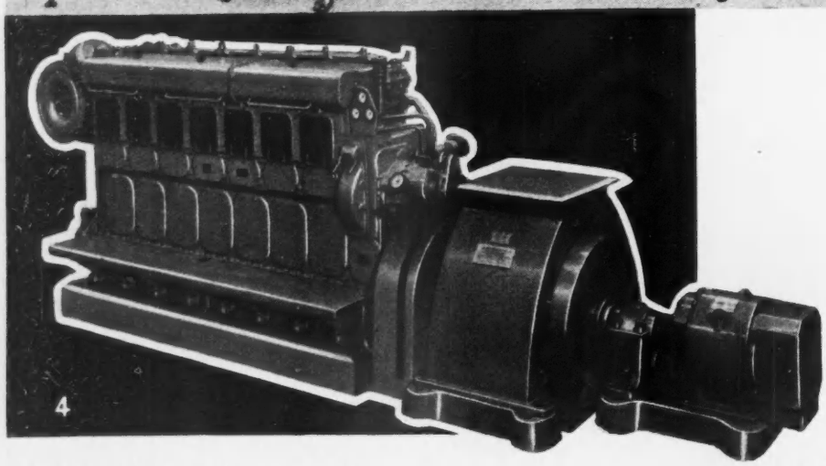

4

The engine generating sets illustrated are:-

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(2) 5-cylinder, 660-b.h.p., 500-r.p.m., type BS37-D pressure-charged engine and 450-kW Allen d.c. generator.

(3) 6-cylinder, 780-b h.p., 375-r.p.m., type T47 engine and 540-kW Allen alternator.

(4) 7-cylinder, 469-b.h.p., 600-r.p.m., type BS12 pressure-charged engine and 322-kW Allen alternator.

TYPE T47 (normally aspirated)
Two-stroke : 312 to 1040 b.h.p. (216 to 720 kW)
Speeds — 300 — 375 r.p.m.
(Built under licence from Harland & Wolff Ltd.)

TYPE S37-D (normally aspirated) and
TYPE BS37-D (pressure charged)
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Speeds — 428 to 500 r.p.m.

TYPE S12 (normally aspirated) and
TYPE BS12 (pressure charged)
Four-stroke : 112 to 640 b.h.p. (75 to 440 kW)
Speeds — 500 to 750 r.p.m.

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Four-stroke vee form : 225 to 1068 b.h.p. (155 to 732 kW)
Speeds — 500 to 750 r.p.m.

All engines may be run at lower speeds with reduced outputs and arranged for remote starting and stopping, or completely automatic control.

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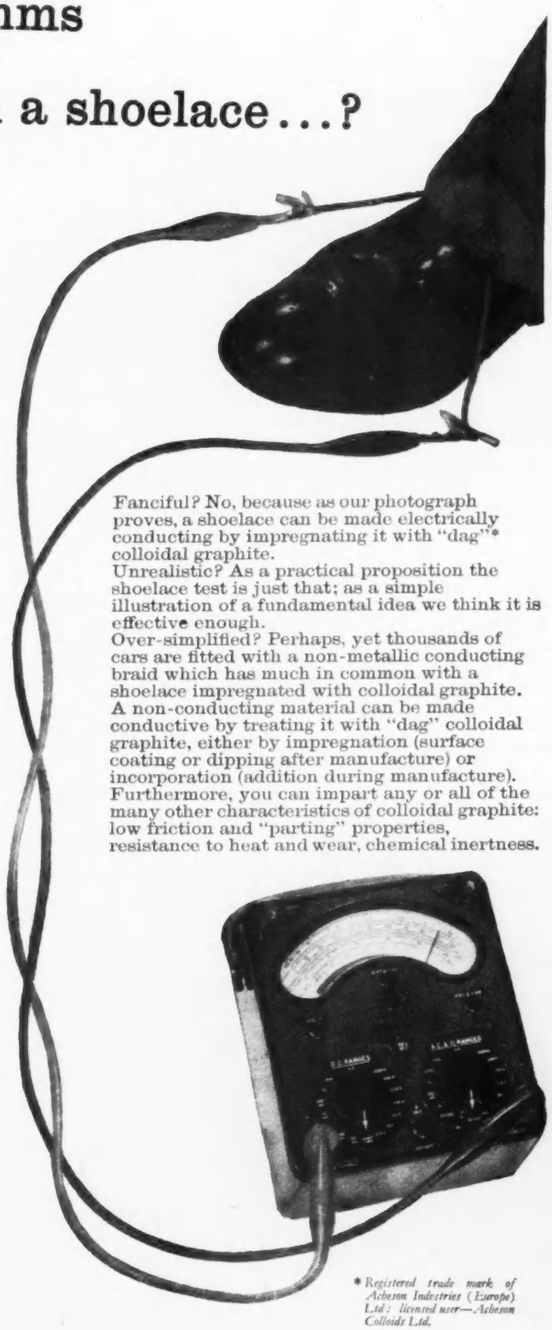
how many ohms in a shoelace...?



Fanciful? No, because as our photograph proves, a shoelace can be made electrically conducting by impregnating it with "dag"* colloidal graphite.
Unrealistic? As a practical proposition the shoelace test is just that; as a simple illustration of a fundamental idea we think it is effective enough.
Over-simplified? Perhaps, yet thousands of cars are fitted with a non-metallic conducting braid which has much in common with a shoelace impregnated with colloidal graphite.
A non-conducting material can be made conductive by treating it with "dag" colloidal graphite, either by impregnation (surface coating or dipping after manufacture) or incorporation (addition during manufacture).
Furthermore, you can impart any or all of the many other characteristics of colloidal graphite: low friction and "parting" properties, resistance to heat and wear, chemical inertness.

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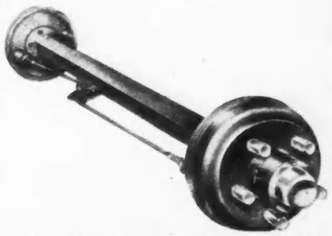

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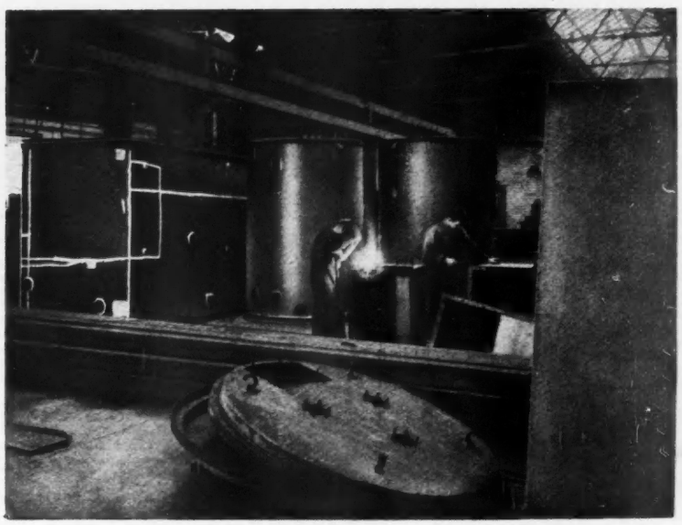

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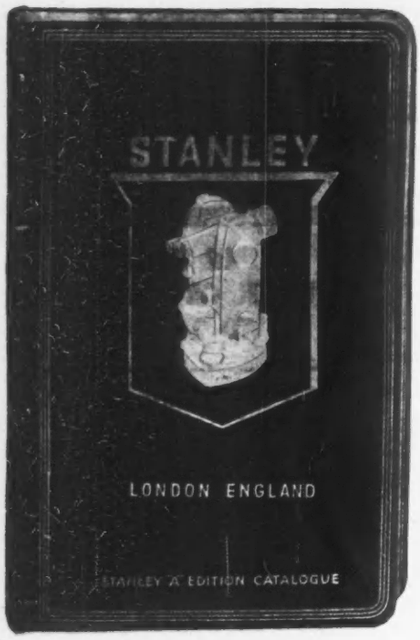

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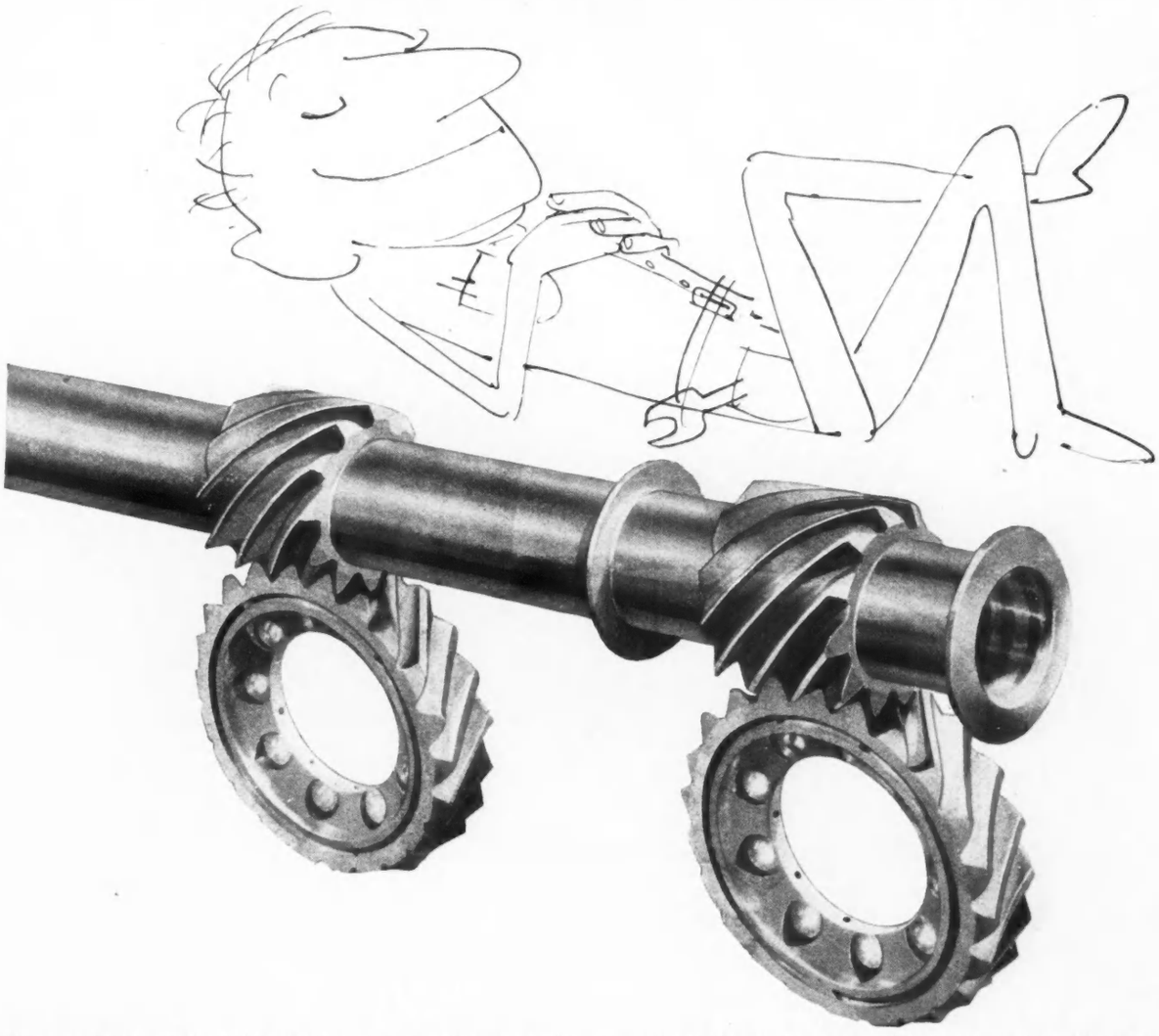

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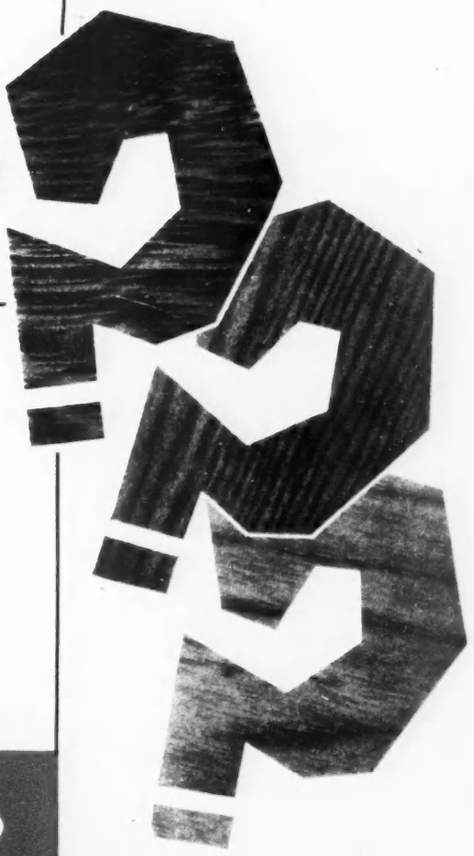

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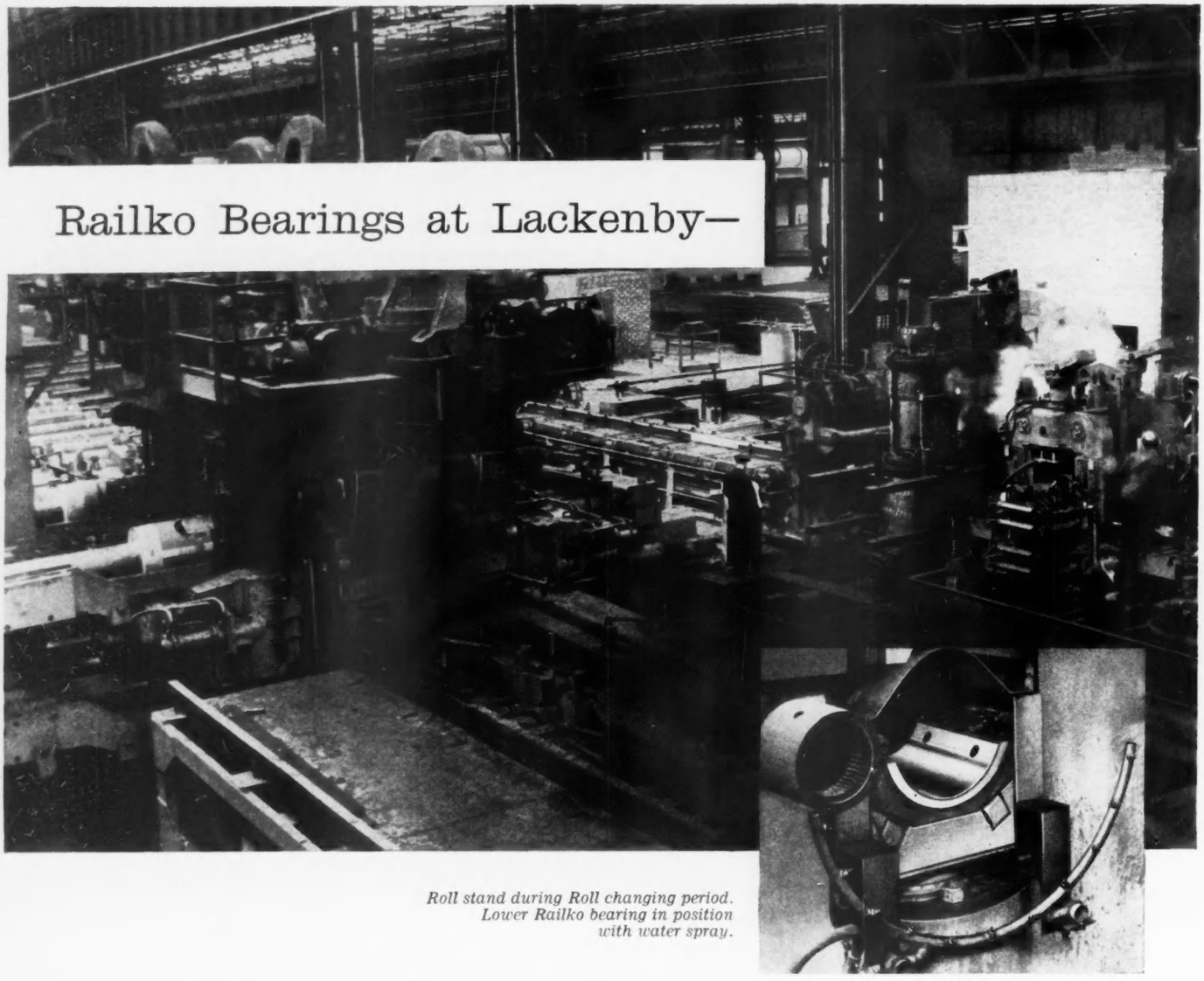

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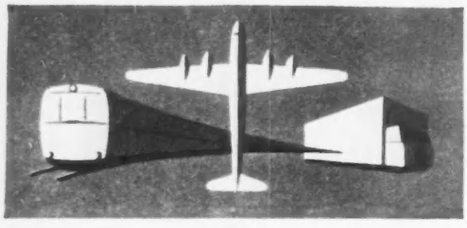

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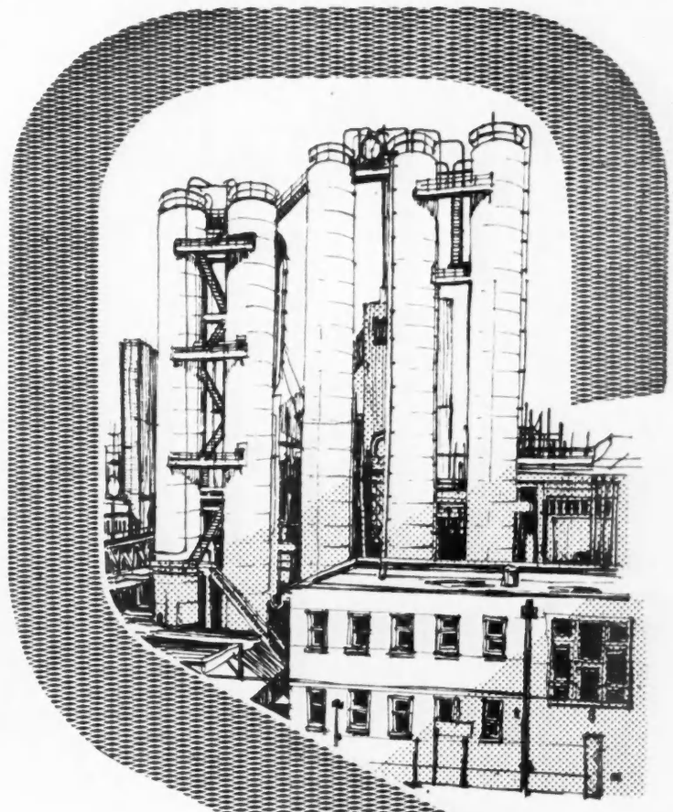

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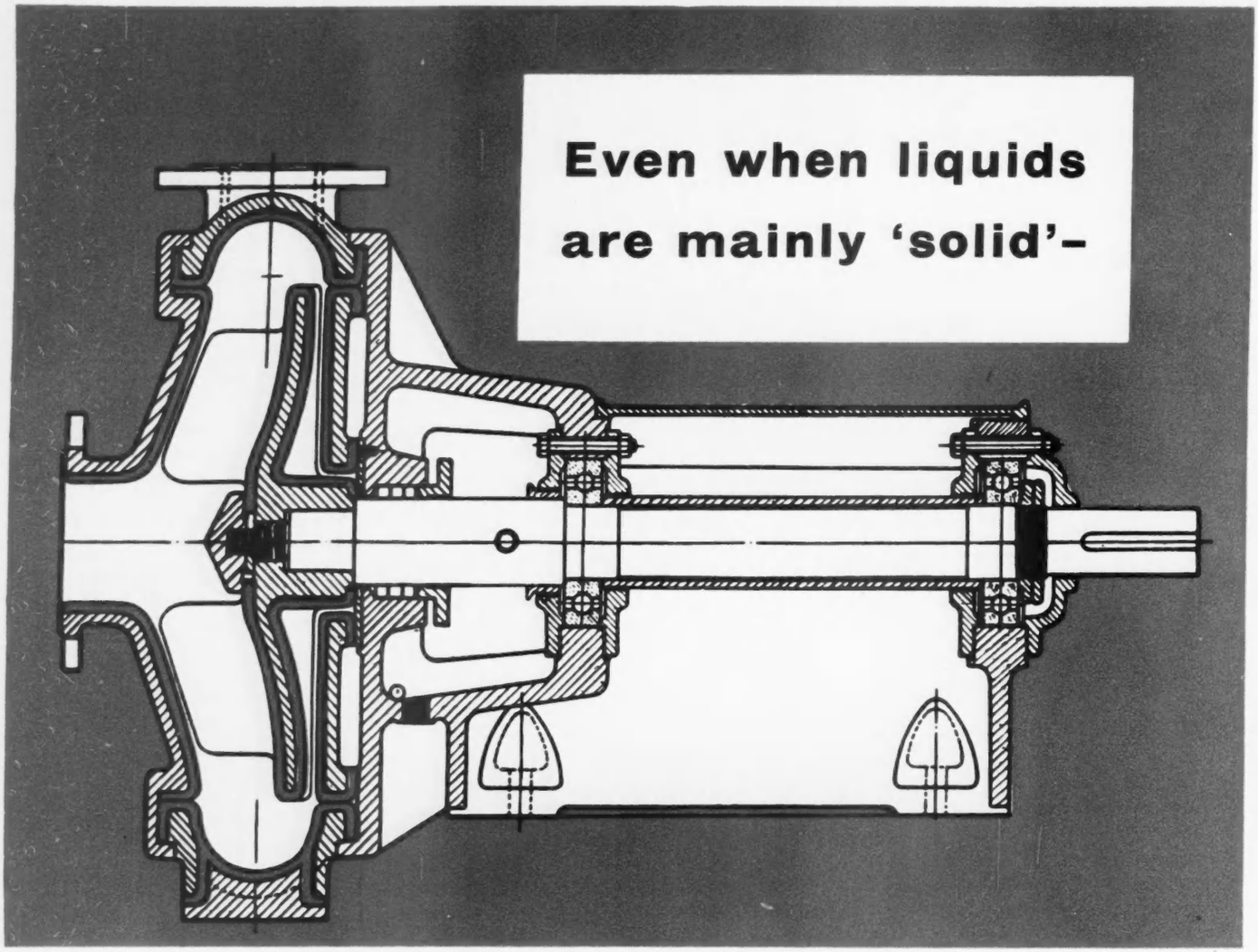

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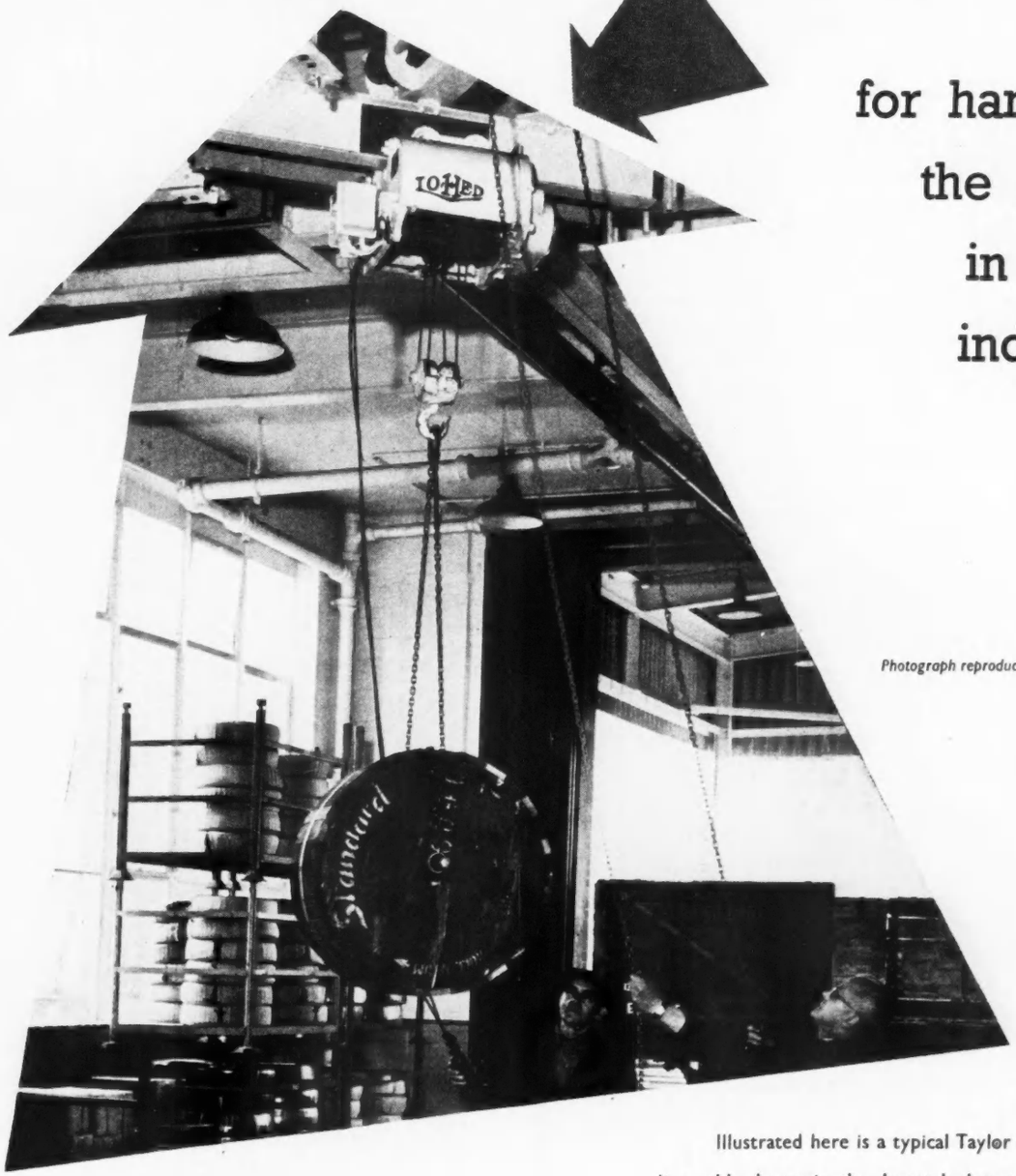

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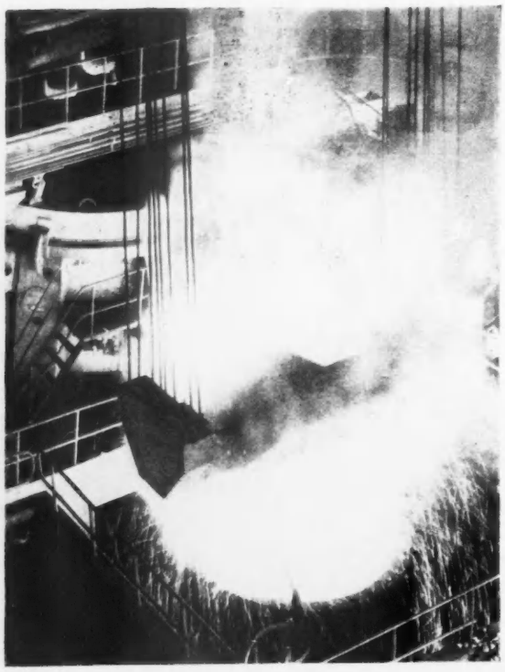

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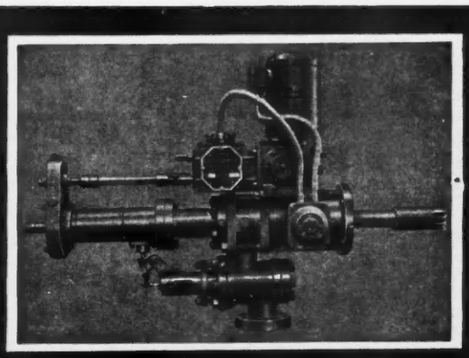

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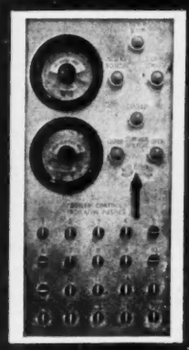

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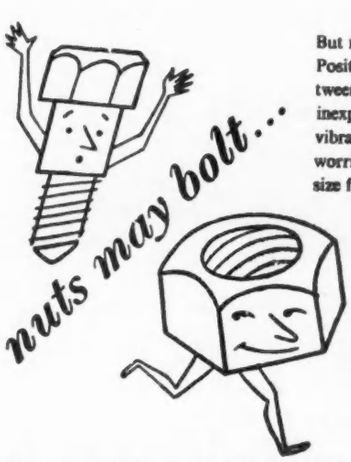

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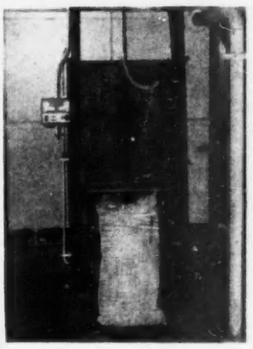

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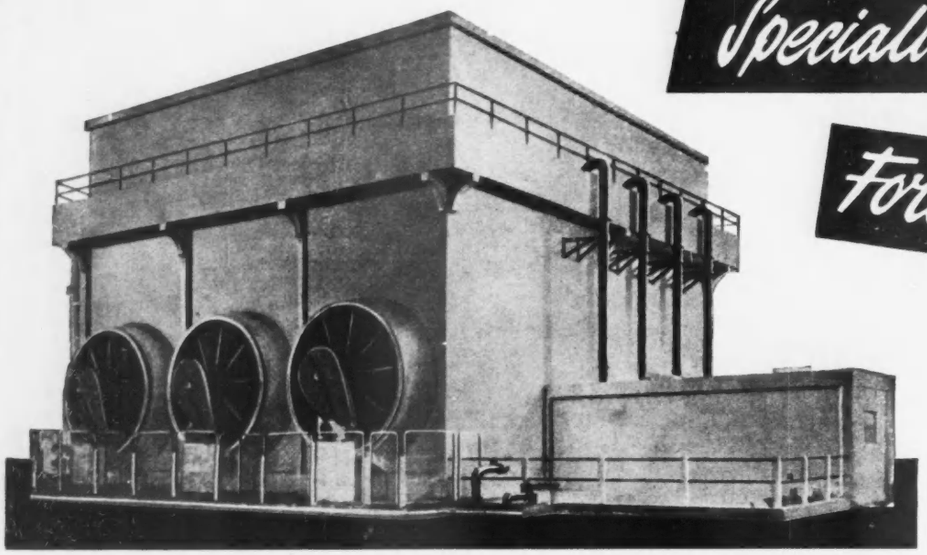

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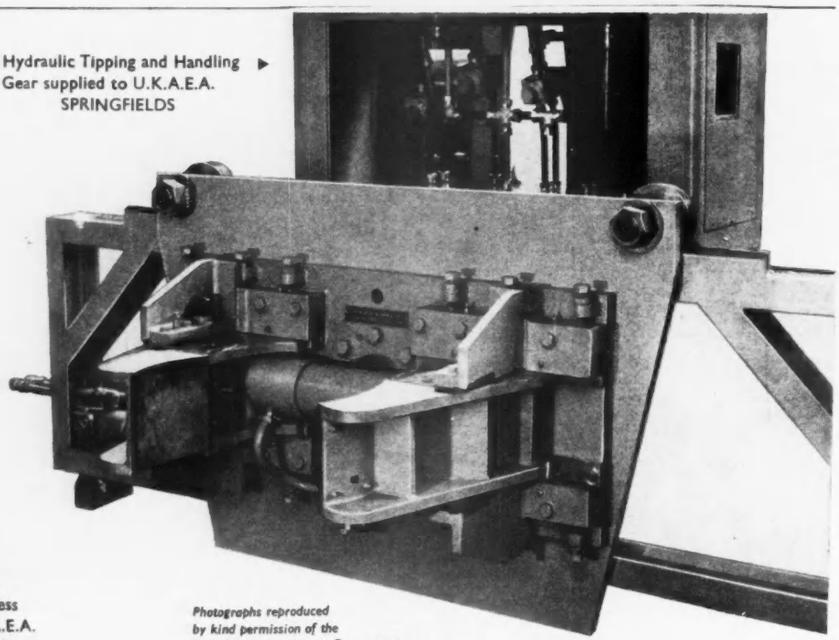

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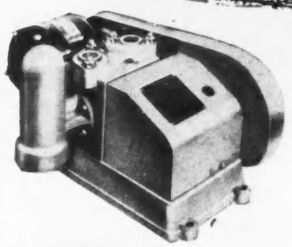

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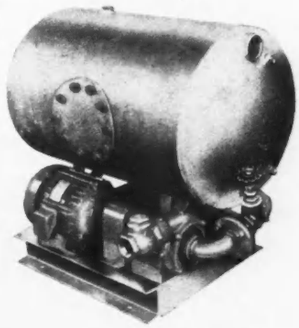

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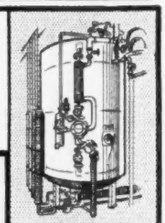

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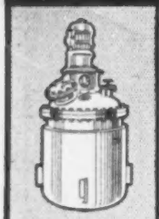

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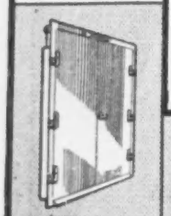

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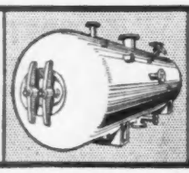

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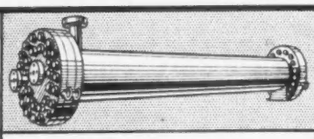

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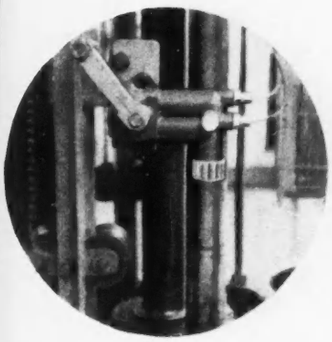

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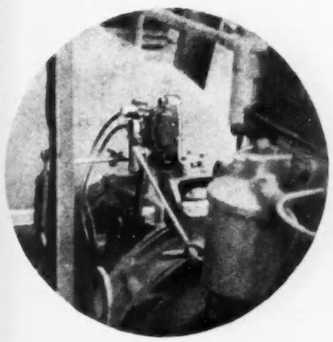

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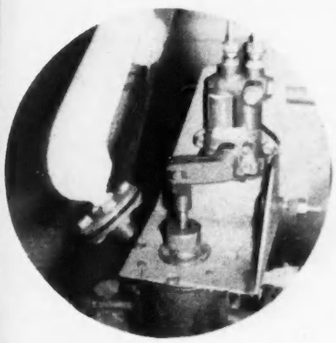

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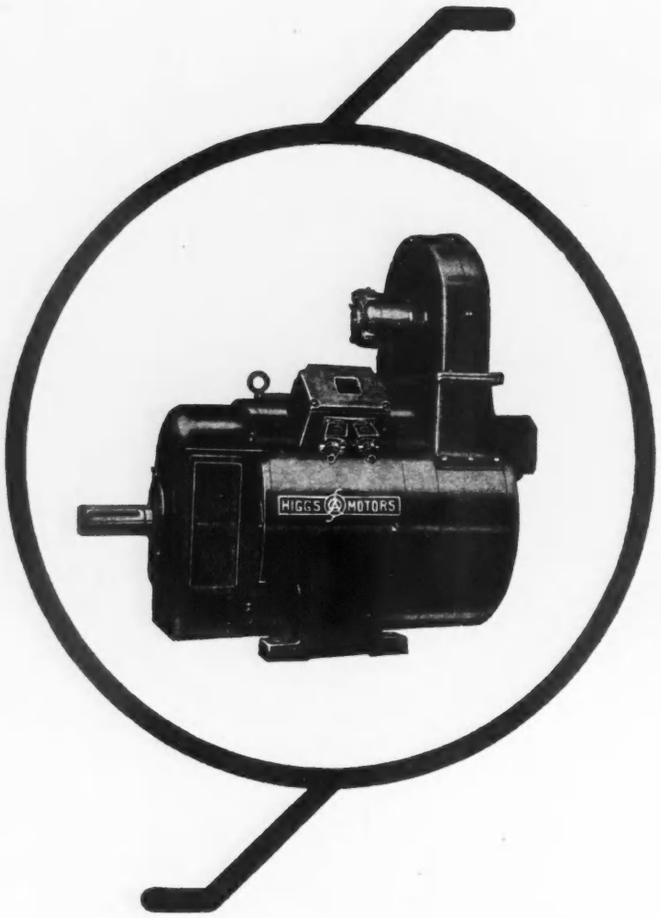

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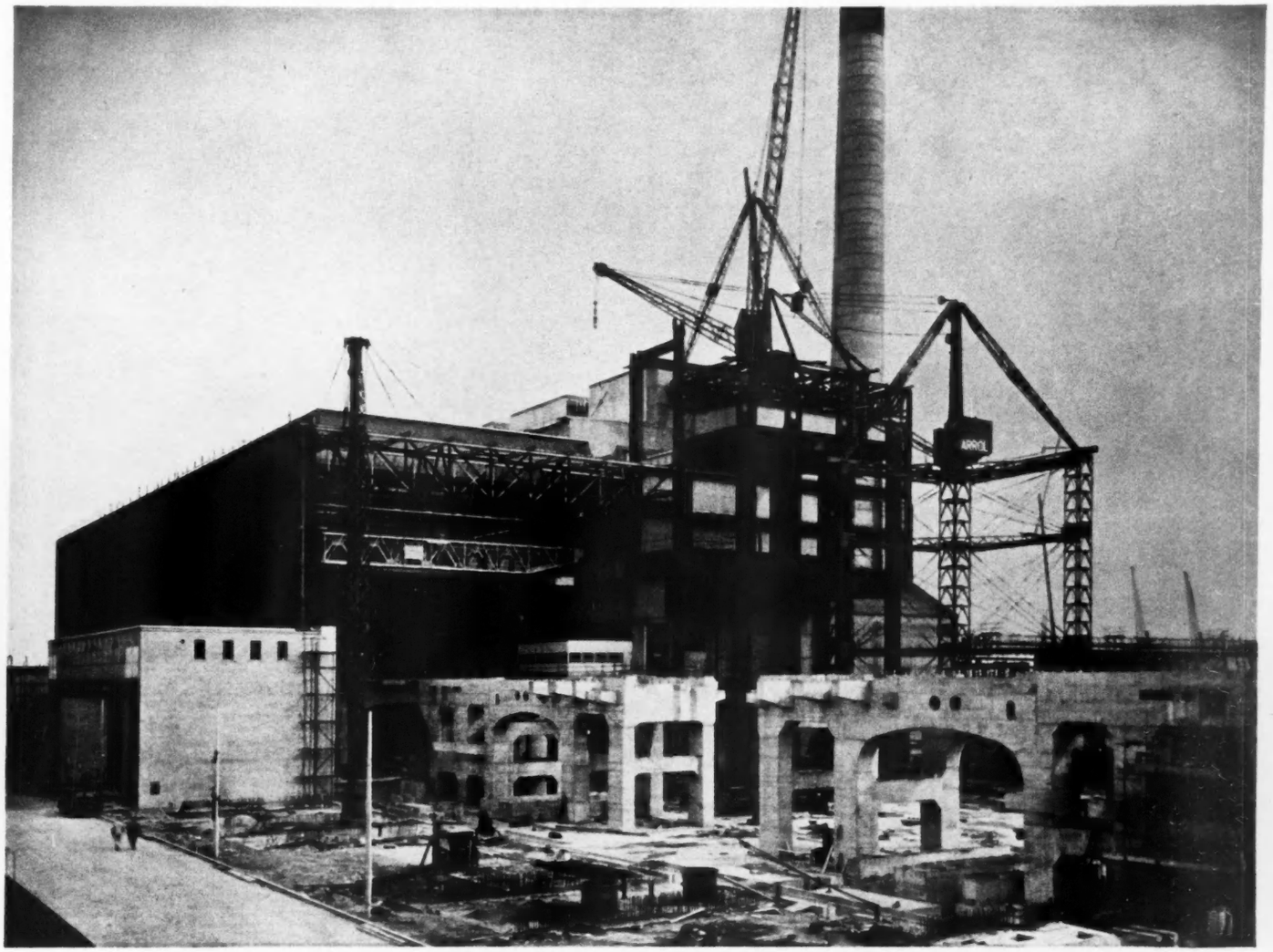

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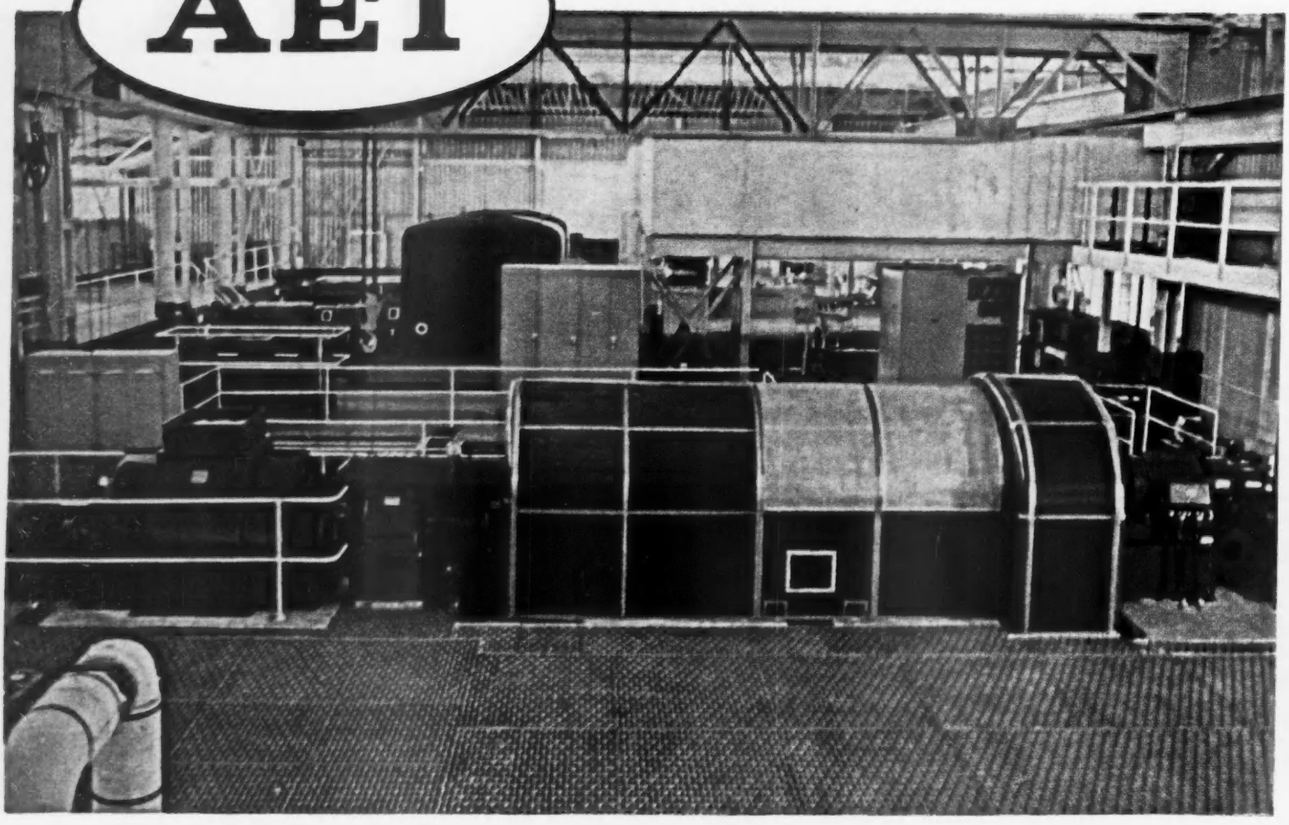

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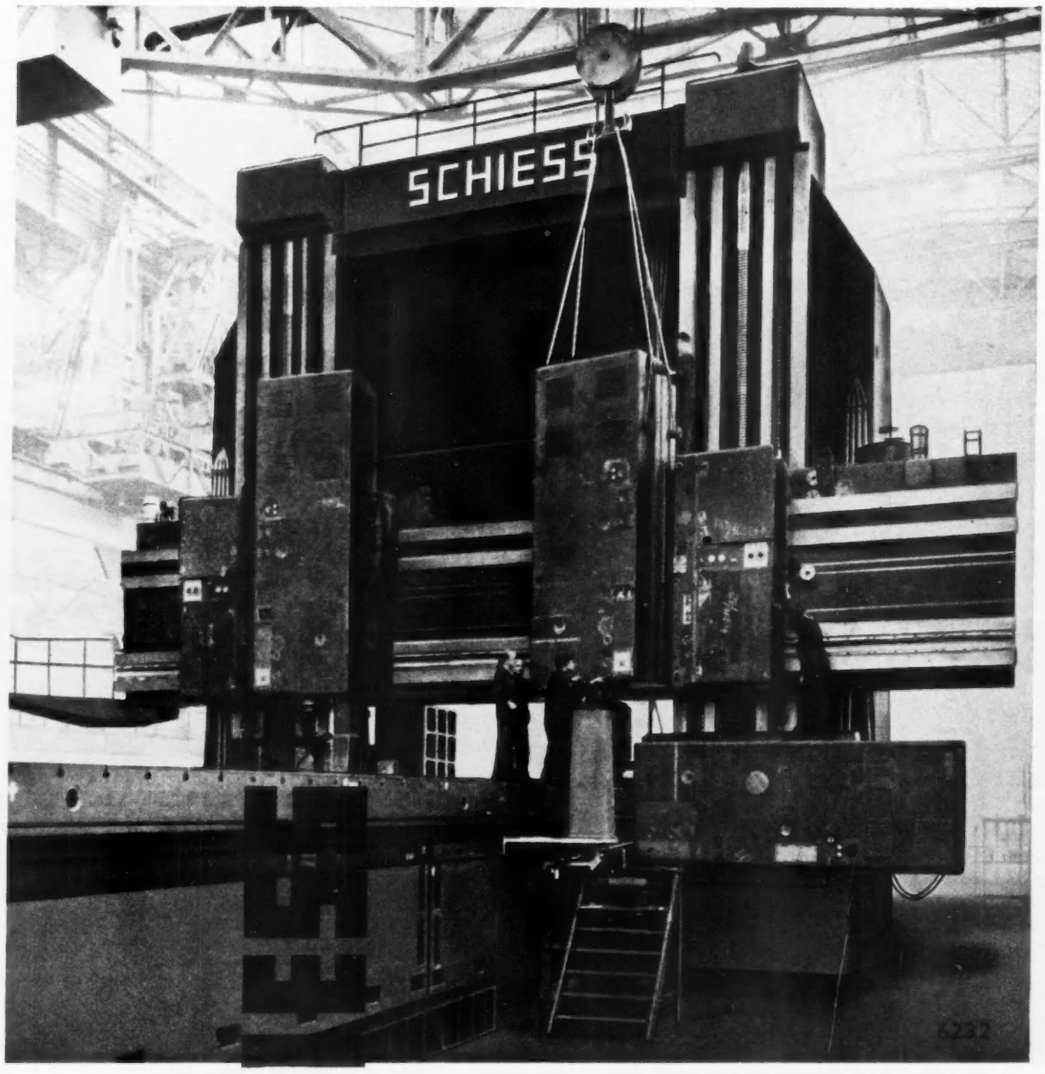

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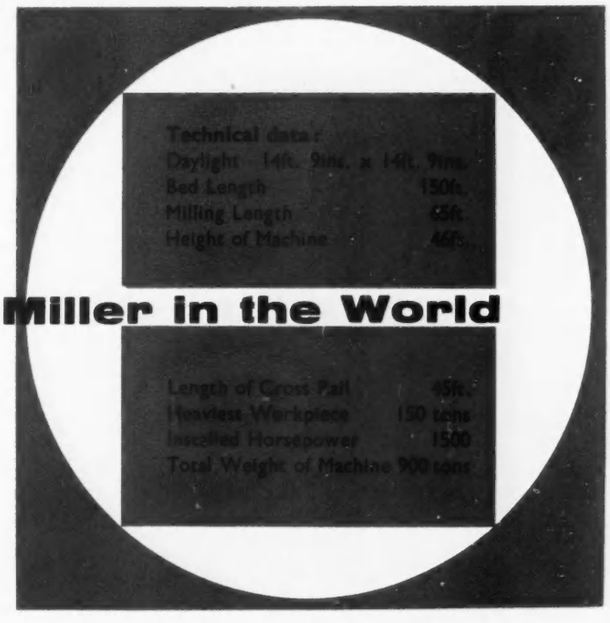
Technical data:
Daylight 14ft. 9ins. x 14ft. 9ins.
Bed Length 150ft.
Milling Length 65ft.
Height of Machine 46ft.
Length of Cross Rail 45ft.
Heaviest Workpiece 150 tons
Installed Horsepower 1500
Total Weight of Machine 900 tons

For a description of this machine please see THE ENGINEER dated January 23rd, page 156

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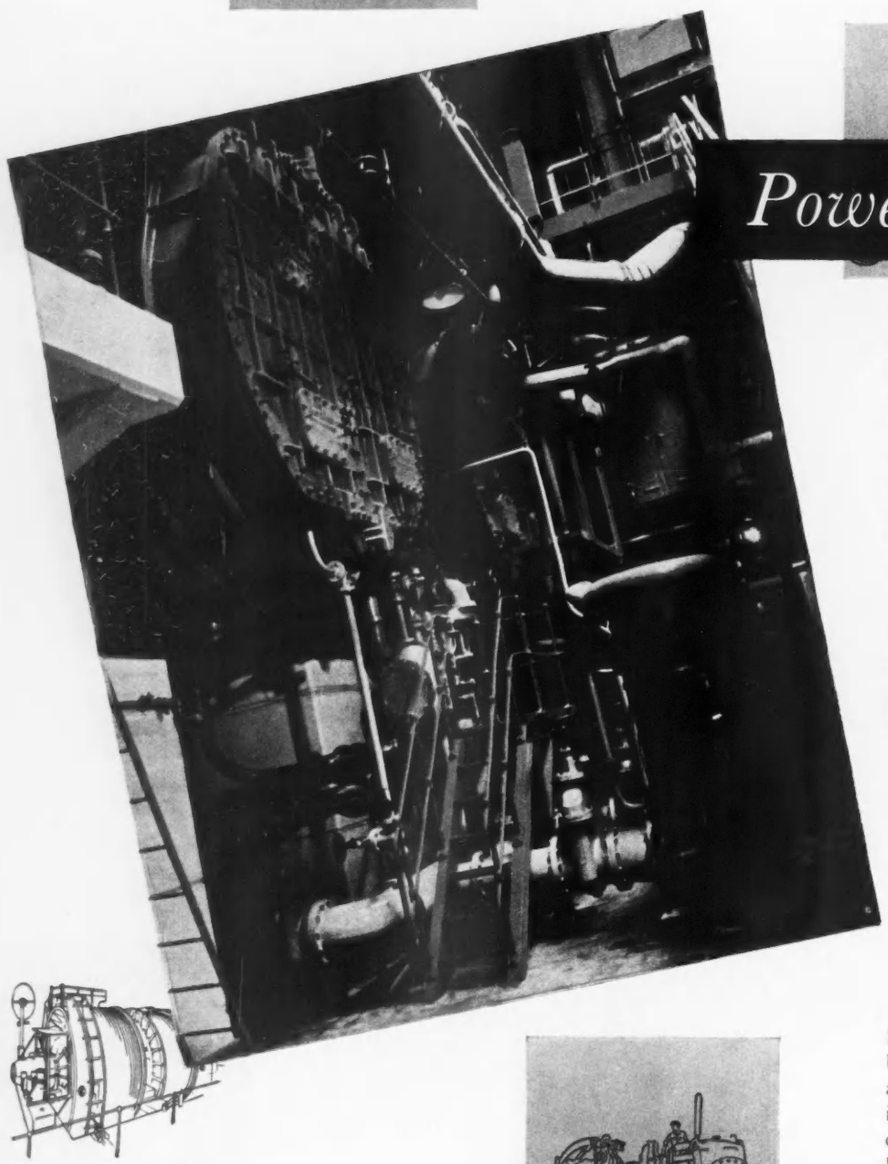
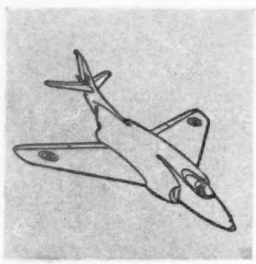
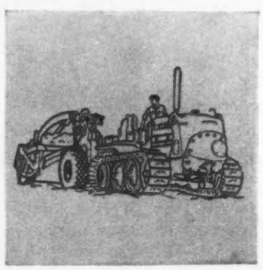
ENGINEERING WITH A BACKGROUND

Power Station Plant

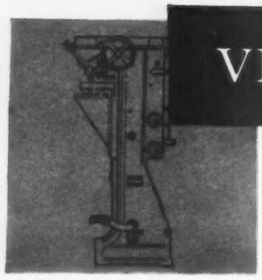


In developing power station auxiliary plant to match the advances in high efficiency turbo-alternators and boilers, Vickers-Armstrongs can draw on an outstanding background of engineering achievement. History-making aircraft like the Viscount and Valiant... fast ocean liners such as the 29,000-ton 'Orsova'... these are headline news. Yet, in their own fields, hundreds of other products of Vickers-Armstrongs are equally important. Whether complex or simple, each shares the same background of outstanding design and sound construction: each solves critical engineering problems.





Power station plant designed and constructed by Vickers-Armstrongs is noted for its efficiency and dependability. The range of equipment includes condensers, feed heaters, de-aereators, evaporating plant and circulating water pumps. In the last few years, the contracts received by the company for this type of plant from the Central Electricity Authority and from overseas organisations involve power stations whose total output is nearly 3,000,000 kW.



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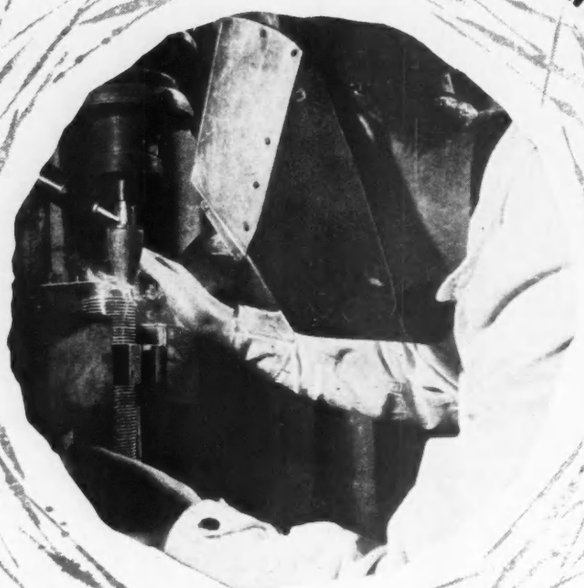

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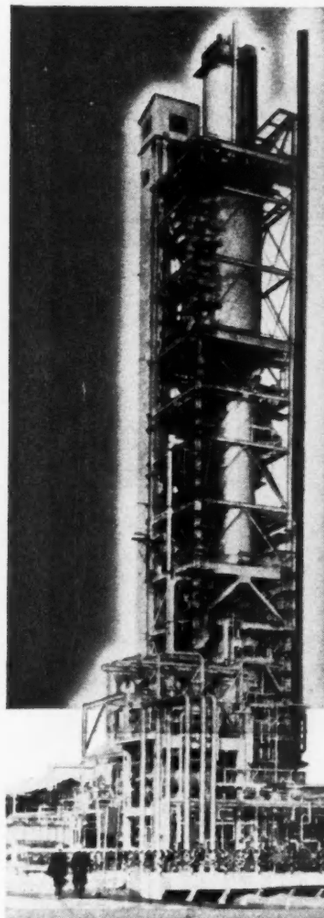

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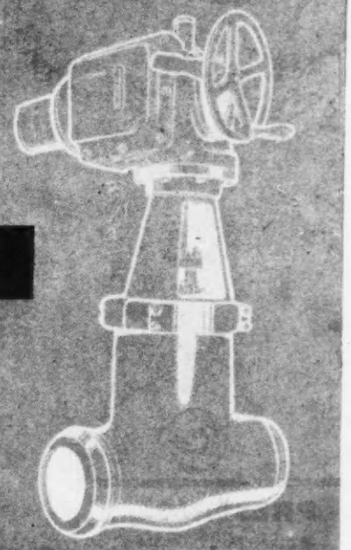

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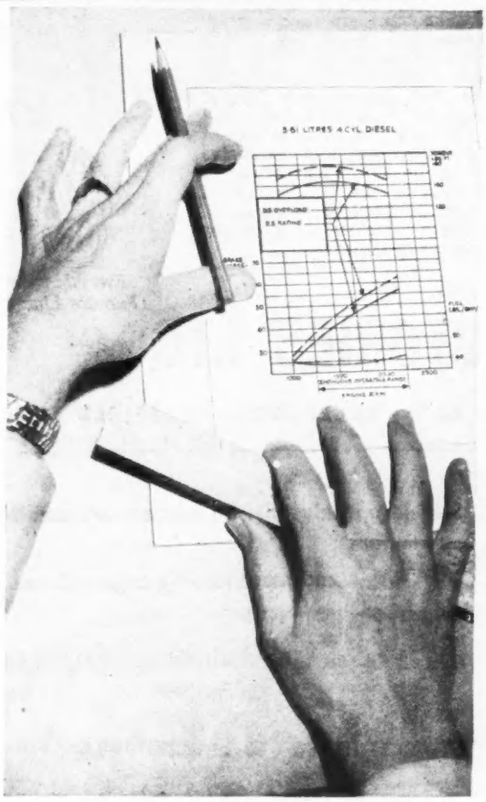

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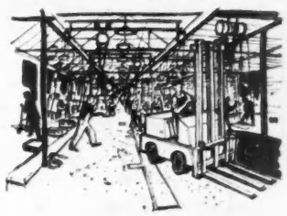

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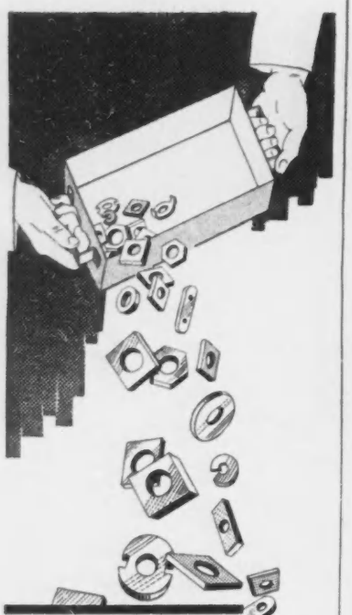

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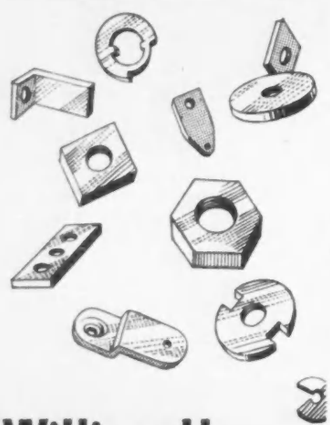

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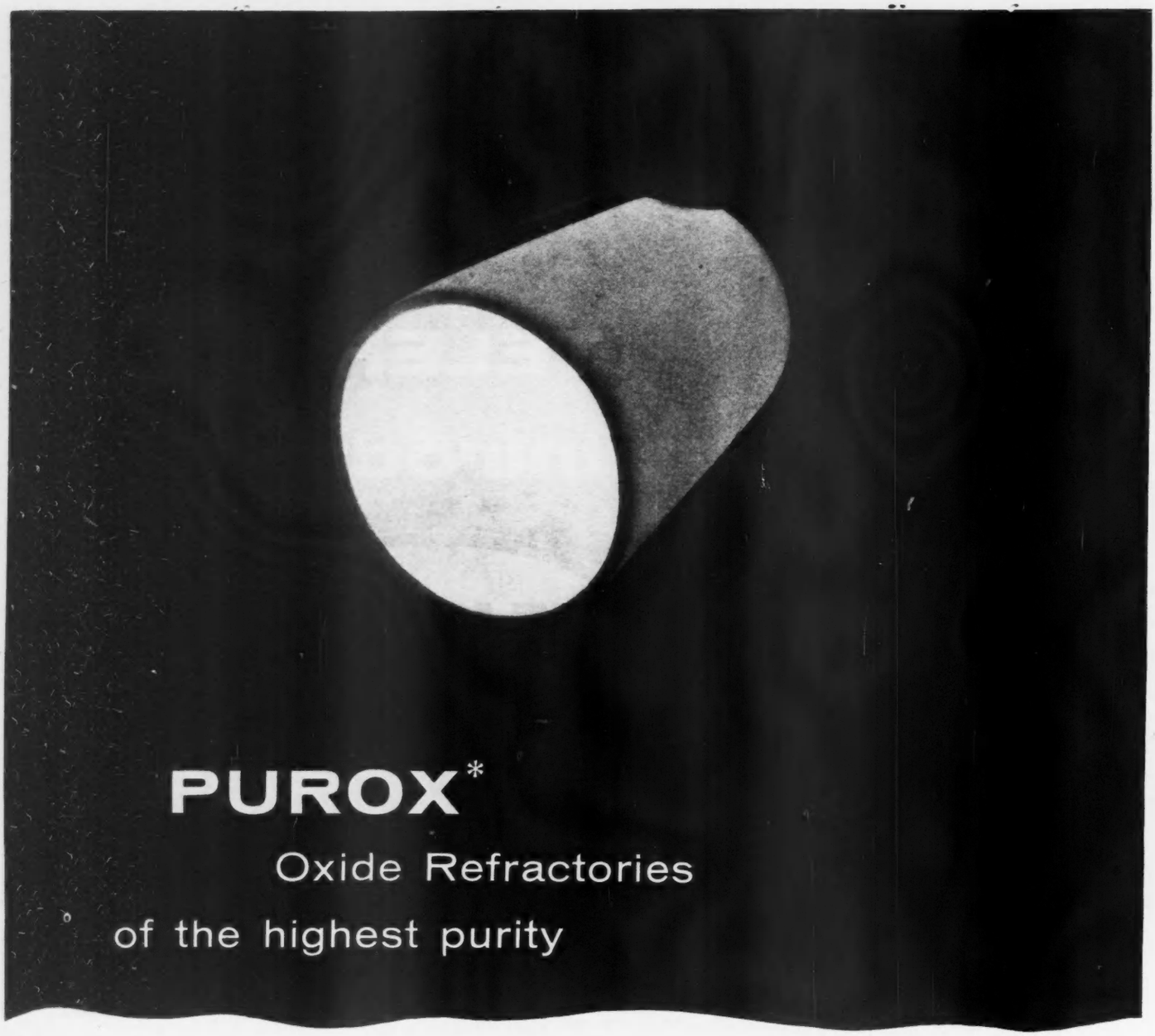

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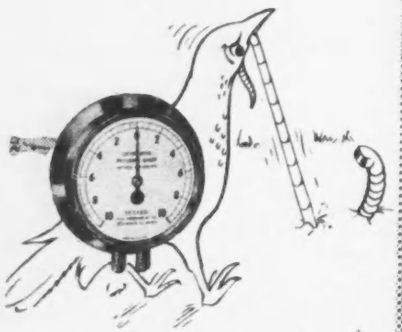

That's how it is just now —but, in the end, the thrush has the greater pull and if it were possible to connect their efforts to a P. & G. differential pressure gauge, the difference would be evident at once.

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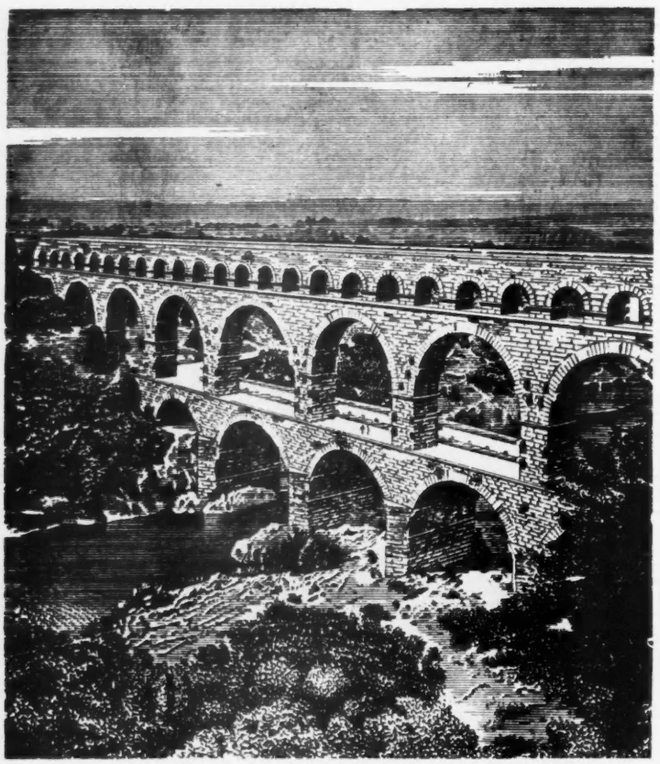

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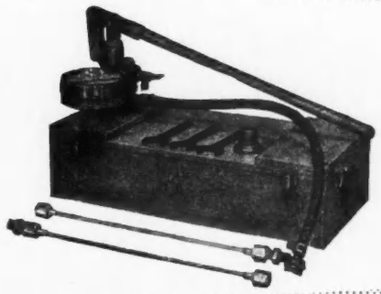

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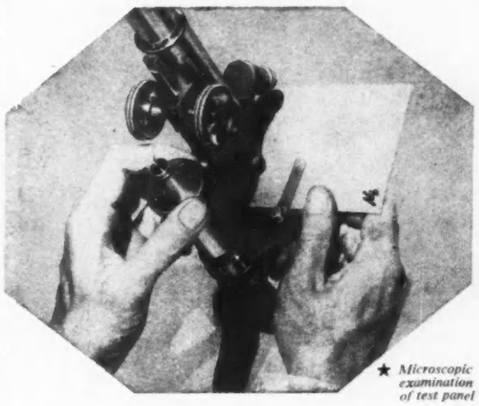

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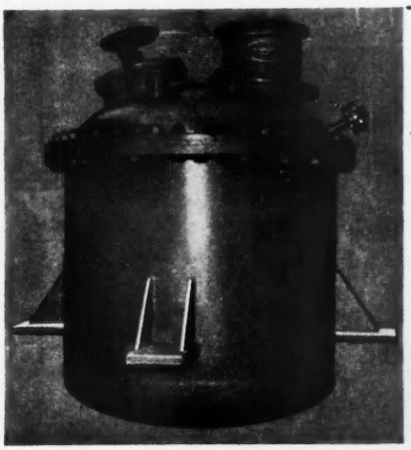

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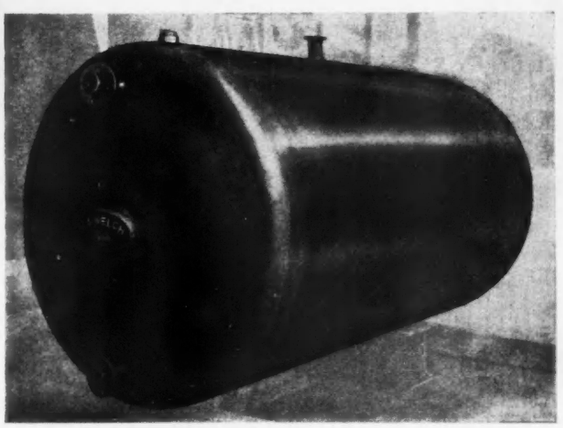

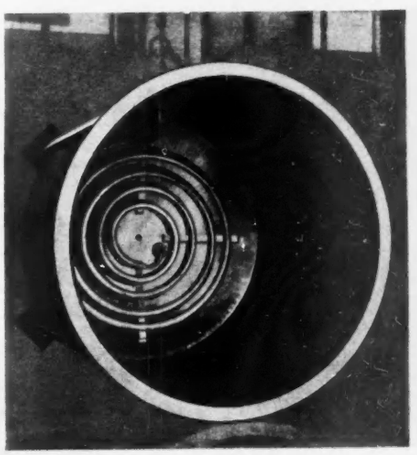

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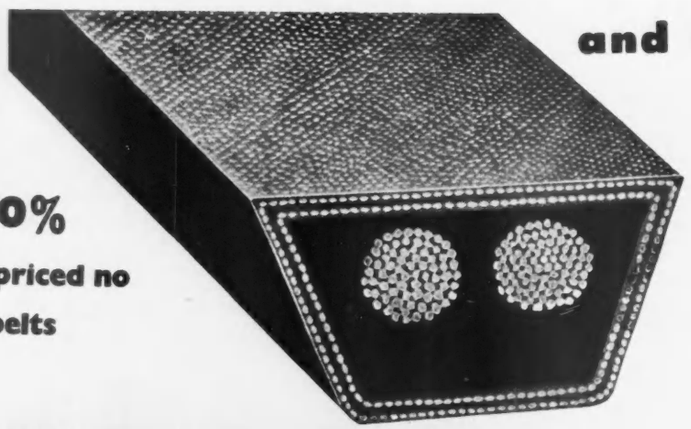

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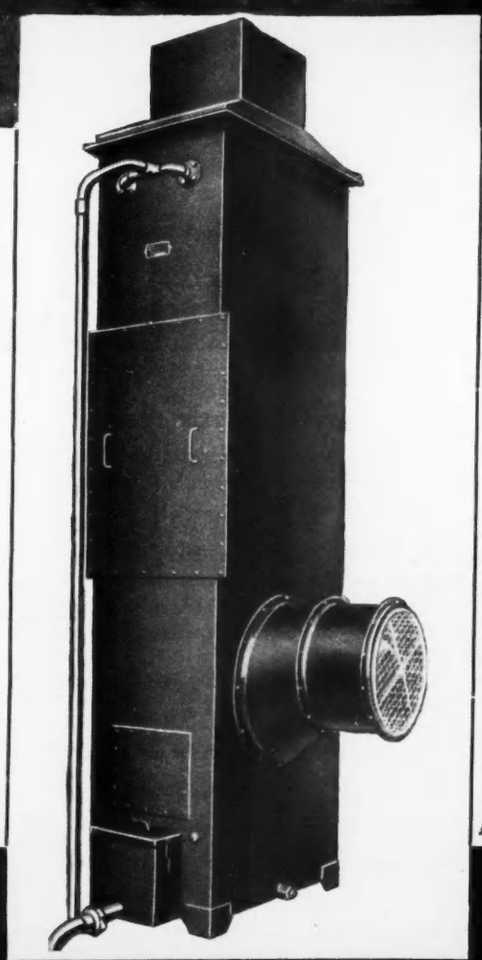
only a ripple on the surface, but ...



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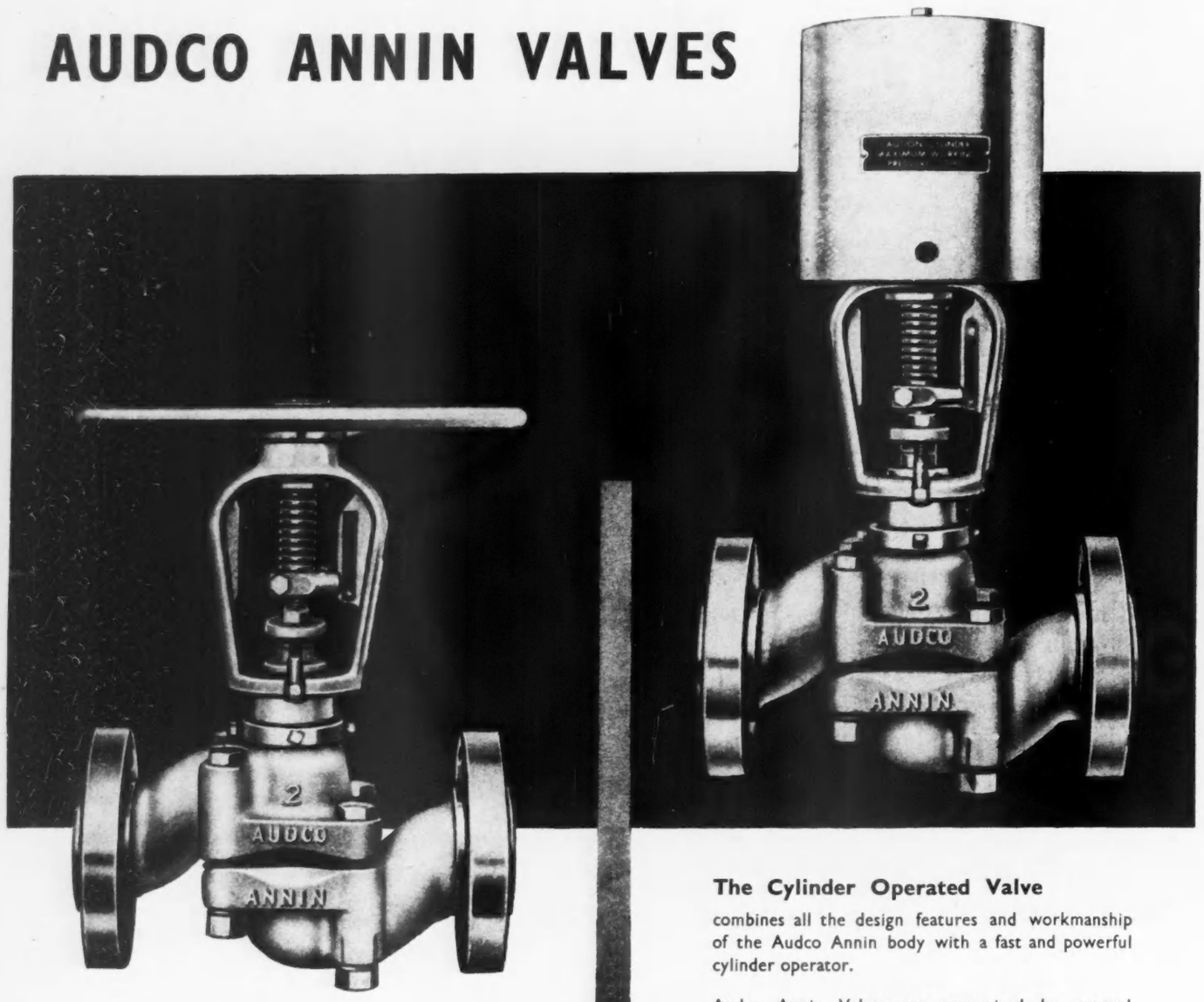

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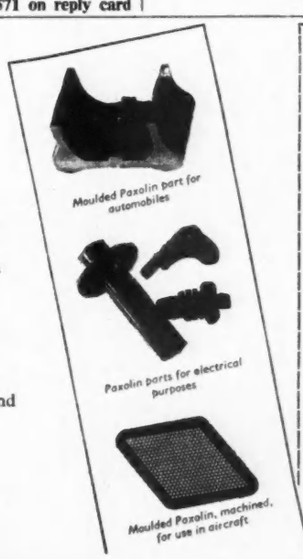
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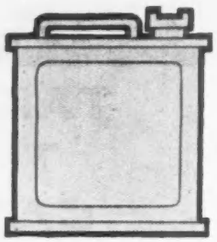
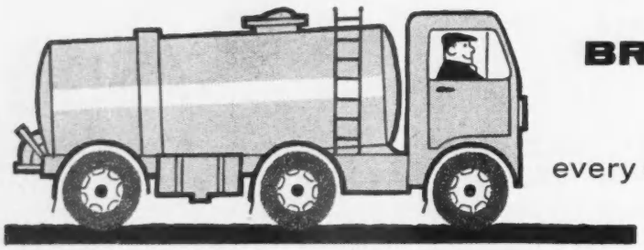


From a can of

PETROL

to a tanker of

TAR



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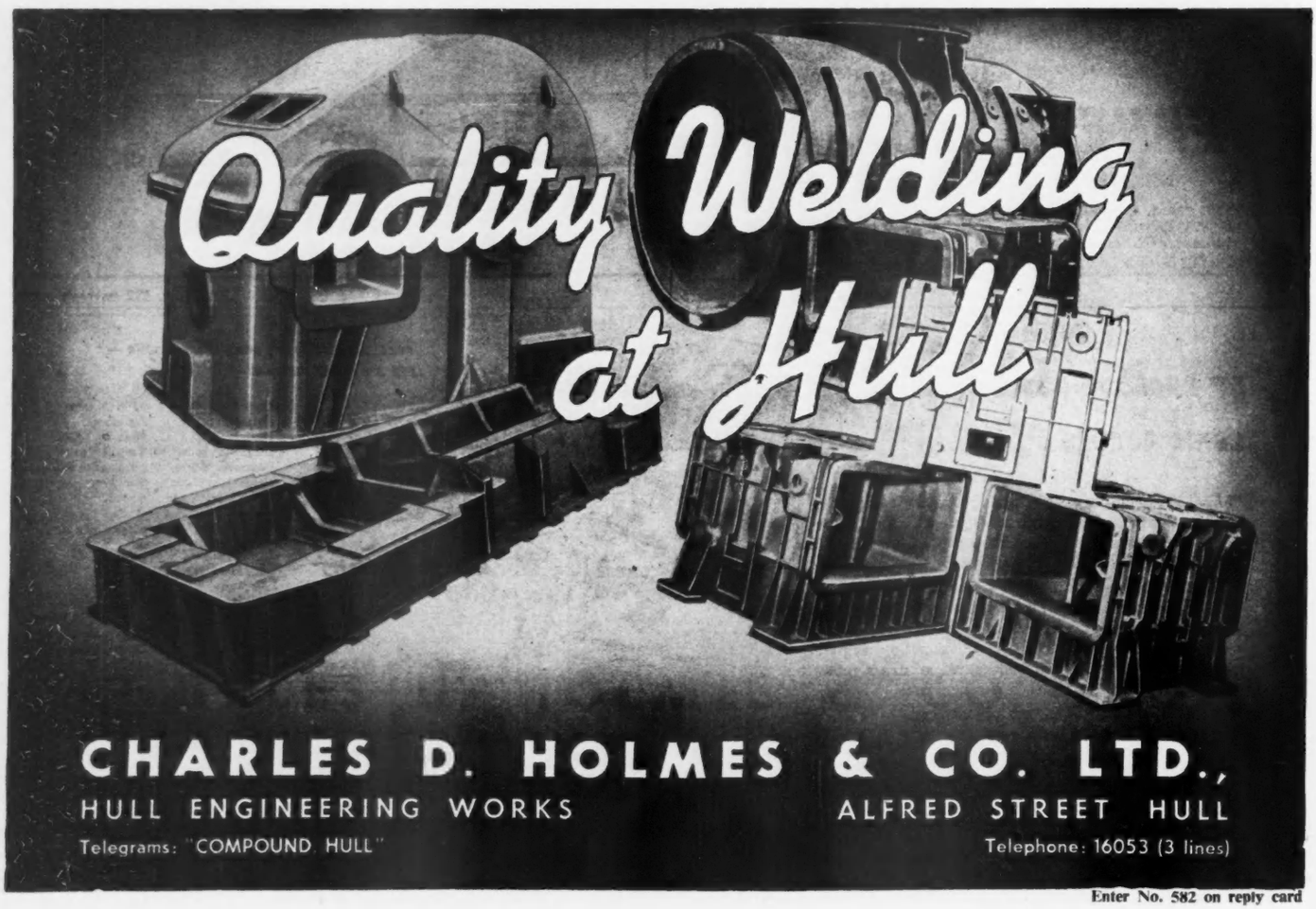

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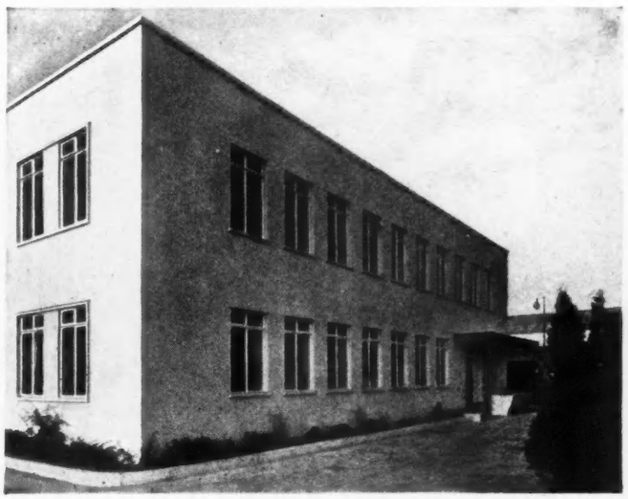

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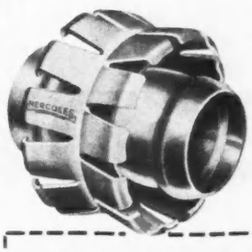

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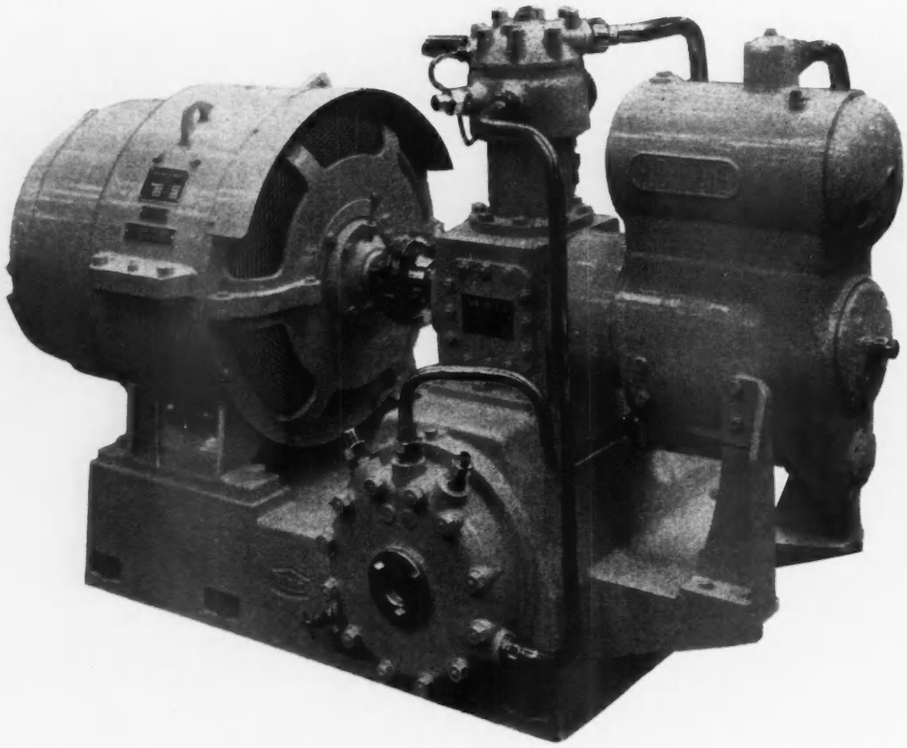

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Weir G. & J. WEIR LTD., CATHCART, GLASGOW, S.4

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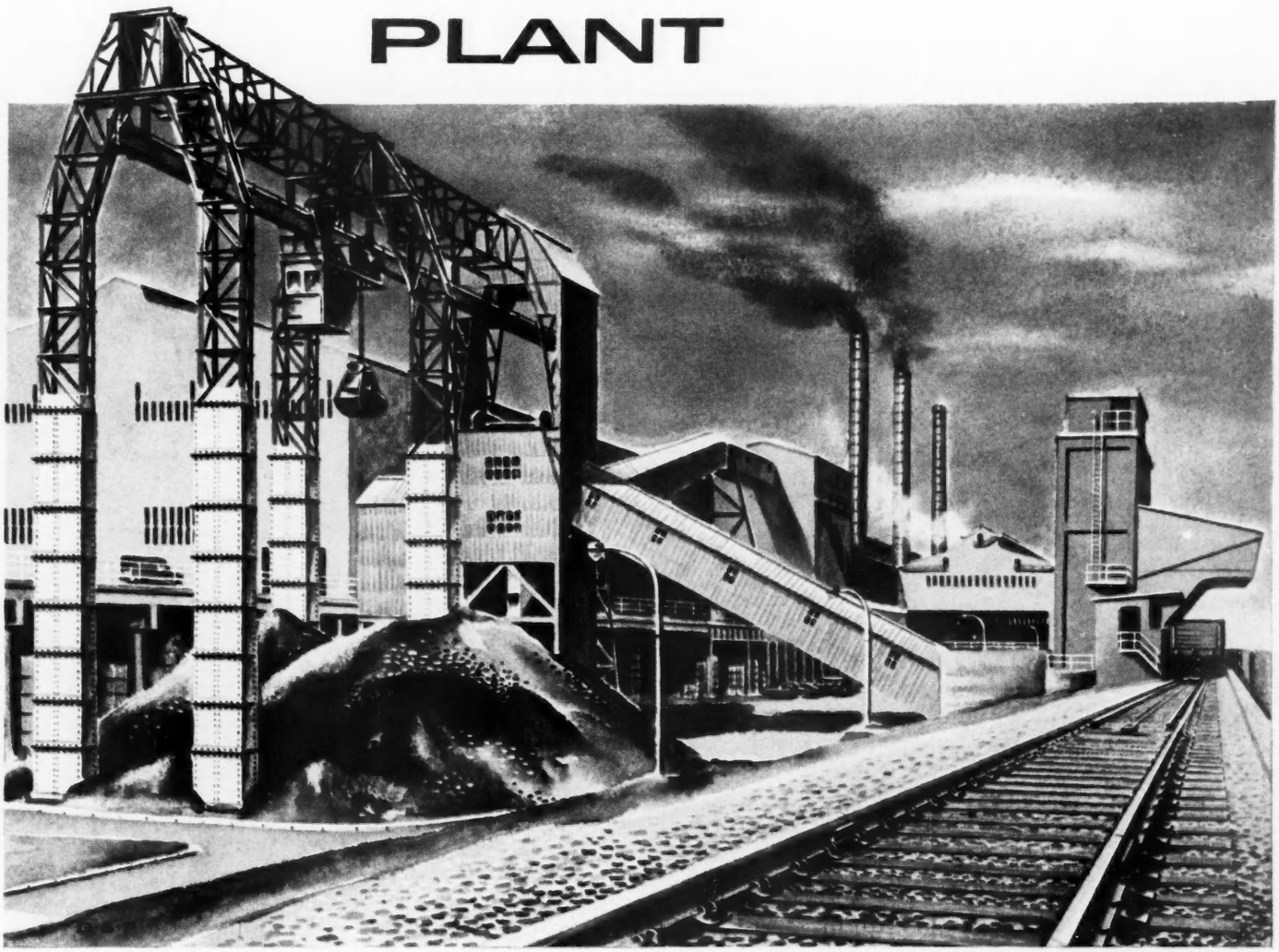

This raw material handling plant at Ravenscraig includes wagon marshalling, a dust trapping tippler, conveyors and a telpher, together with measuring box feeders and pan wagon control.

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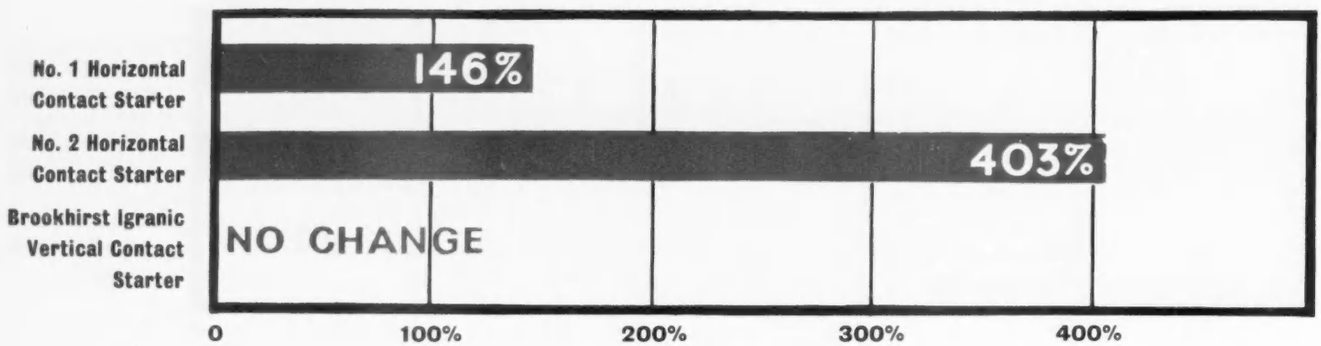

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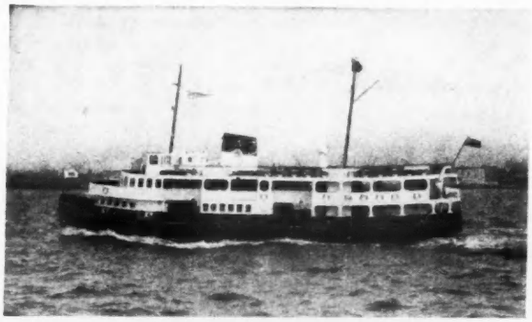

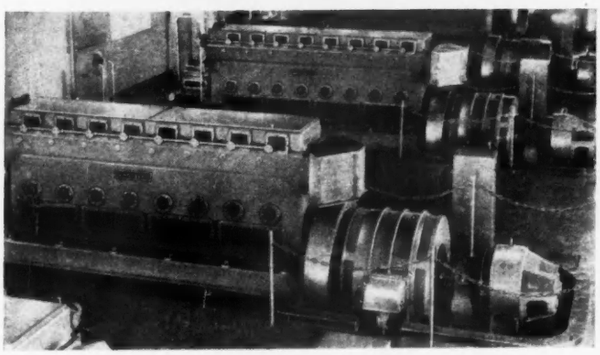

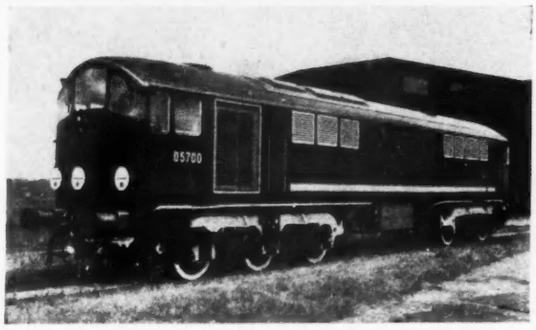

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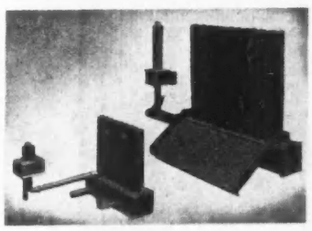

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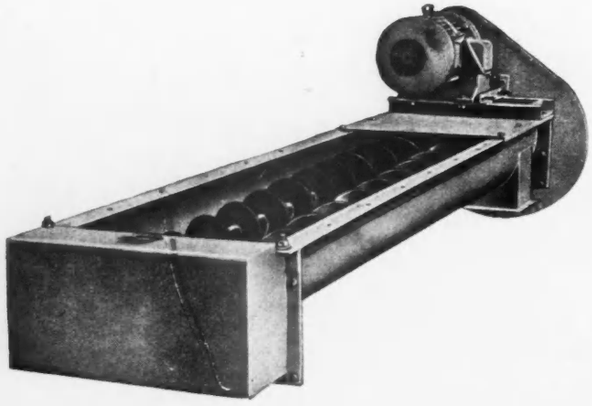

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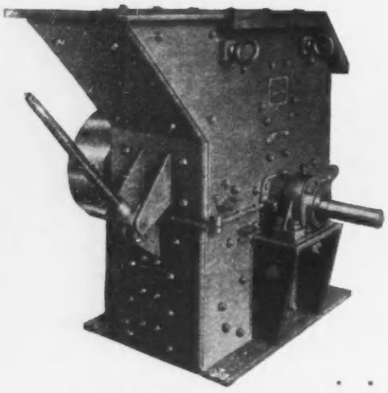

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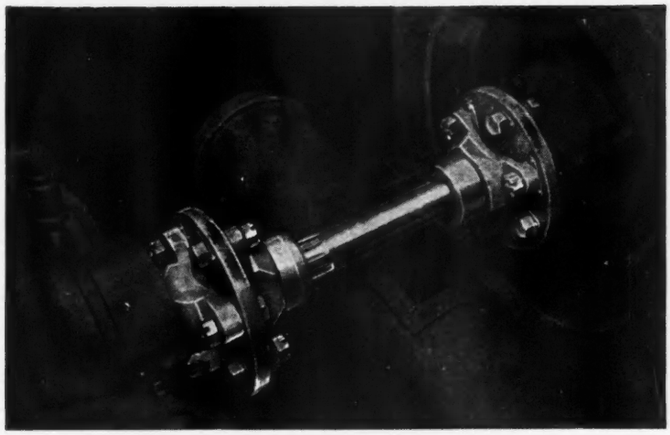

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In 1620 Edmund Gunter, one of a group of English clergymen engaged in the pursuit of mathematical knowledge, introduced 'Gunter's Scales.' These were single lines marked into segments proportional to the logarithms of the numbers. Gunter's Scales inspired the Rev. William Oughtred (1574–1660) to evolve the principle of interchangeable scales by sliding one against the other. Oughtred's instrument was the precursor of the slide rule of today, a device which has made rapid calculation a relatively simple procedure.

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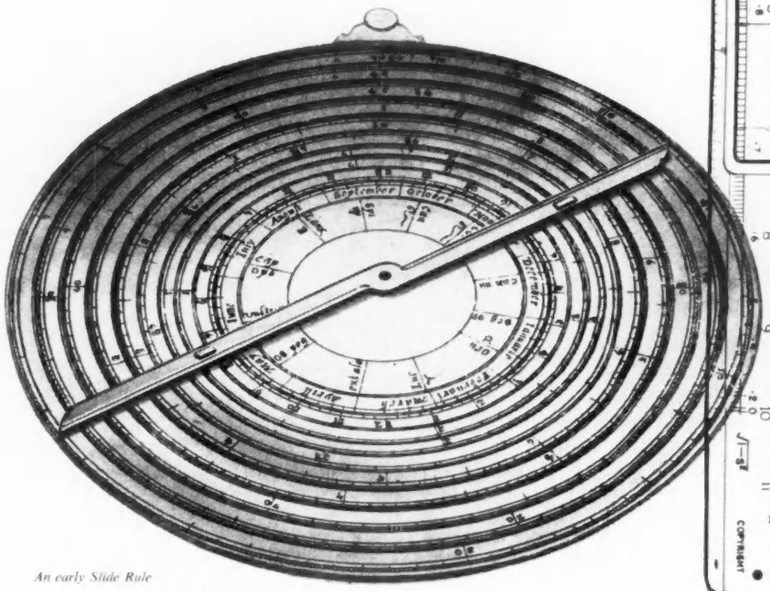
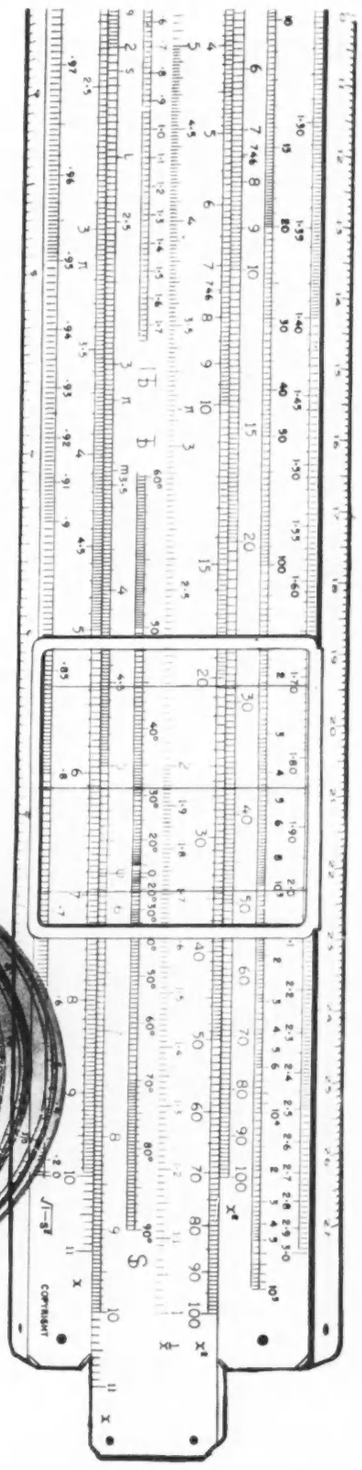


An early Slide Rule
based on Oughtred's principle.
(Property of St. John's College, Oxford, on loan to the Museum of the History of Science, Oxford)



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THE ENGINEER

No. 5419 DECEMBER 4, 1959 VOL. 208

PEOPLE AND POWER

Early last week the Nature Conservancy announced that it had decided to abandon the proposed Dungeness National Nature Reserve. That decision was reached as a direct consequence of the Government's consent to the erection of a nuclear power station in that area. The announcement was made on the Monday of that week; on the following Wednesday Sir Christopher Hinton, Chairman of the Central Electricity Generating Board, presented a paper before the Royal Society of Arts on "Power Production and Transmission in the Countryside; Preserving Amenities." Sir William Holford, Professor of Town Planning, University College, followed him with comments of his own on the same subject. One of Sir Christopher's remarks, though well within the context of power generation, was quite general. It was that because 50,000,000 people living in this small island desire to have a continuously rising standard of living industrialisation must spread, inevitably, into areas hitherto rural in character. There in Sir Christopher's view lies the rub. For thereby the "average" man in Britain feels himself being robbed of his contact with the countryside. Moreover, it becomes useless to argue that a site, for example, for some new power station is not especially beautiful, equally useless even to argue that the site is grim and desolate, and unconvincing to suggest that the erection of a building will add to rather than detract from appearances. An "average" town dweller, who, in Sir Christopher's words "fishes from the beach at Dungeness" does not worry at all that Dungeness is featureless. "In an easterly wind he feels he is exposing himself to the natural forces he has lost in the city." To many engineers, we fancy, properly sited pylons appear to stride grandly across the countryside; they stimulate the imagination in much the same way as roads and railways. The loneliness of a moorland is all the better appreciated because the string of pylons carries the mind away to contrast it with the crowded cities far away under smoky skies. But in Sir Christopher's view "To the average man they are the obtrusive tentacles of industrialisation creeping into a countryside he would prefer to keep free." That kind of objection is seldom voiced at any official inquiry. Objection to the Dungeness site for a nuclear power station, for example, centred around the scientific interest of the region, and the possible effects upon bird life, and upon the flora and fauna in general of the erection and operation of the station; and also upon the presumed unsightliness of the power lines that must spread out from the station. But, of course, to be effective at an Inquiry, objection must be focused upon some concrete thing, some definite fact, or some special feature of the site. An expression of a general emotional dislike of spreading industrialisation is unlikely to prove impressive if only because in Sir Christopher's words "to object to industrialisation would be to deny the country any future."

At such inquiries there are almost invariably suggestions that there are plenty of unexceptional sites elsewhere. But Sir William Holford gave the answer to that one. "We are approaching a situation now where the greater part of the land not already built up has a rarity value, and where every individual site can claim to be in a greater or lesser degree unique; in its history, geography, ecology, architecture, physiography, scientific interest or beauty. The Generating Board, or so it seems to me, can never be dogmatic in resisting this claim. It cannot say that the generation and transmission of electricity is always more valuable than the preservation of these amenities. At the same time, it knows very well that electricity is basic to the whole existence of this country in the twentieth century, and, therefore, to the preservation of any amenities at all; and as under the Electricity Act, it has to provide power as efficiently and economically as possible, it stands to reason that efficient and economic sites must be found." He also gave an answer to the emotional problem "where the dislike of all structural manifestations of electricity is due to strong psychological resistance to the invasion of nature by the industrial machine." Good design can, of course, do nothing to lessen this dislike. Nevertheless "effective design can do something . . to compensate in some degree by offering an alternative amenity." How very much we agree !. For in reality there is very little that is "natural" in the appearance of this ancient land of Britain. Only the contours remain more or less undisturbed; all the rest is man-made or man-permitted. We in this twentieth century should have the courage to change the scenery just as our forefathers did. It is wrong to do so only if it is done without thought and with no care for amenity. In that context it must be particularly gratifying to the C.E.G.B. that part of the hydro-electric scheme at Dolgarrog has received an award from the Civic Trust under a scheme for making such awards "to encourage owners, architects, engineers, planners, builders, and the public to take a greater interest in the appearance of their towns and villages." The Trust remarks of the Board "Any Authority that seeks professional advice of the standard evidenced here is to be congratulated; engineering structures treated as sensitively as this entail no destruction of the countryside."

ESTUARIAL POLLUTION

From time to time within the last few years we have drawn attention to the filthy condition of many of the estuaries around Britain's coasts. Notable amongst estuaries which are heavily polluted are those of the Tyne and the Tees; and recent studies of the Thames have revealed that at certain states of the tide water above London Bridge—that is in the very heart of the City—is wholly deoxygenated. Other estuaries, though less

badly polluted at present, show an ominously deteriorating trend. That trend is opposite to that occurring in the non-tidal sections of most rivers. Inland, thanks to the work of River Boards, assisted by the often more militant activities of the Anglers Co-operative Association, and much more often than not with the co-operation of industry, there is evidence of improvement ; slow, maybe, but still improvement. The reason for that contrast is largely to be traced to the limitation of the powers of River Boards under an Act of 1951. The Act lays it down that it shall be an offence if a person " causes or knowingly permits to enter a stream any poisonous, noxious or polluting matter." But there are so many escape clauses that in effect the Act is much less strong than it appears to be ; and, of special relevance here, estuaries are not streams within the meaning of the Act. Thus, though River Boards have proved able to improve the state of many rivers, if only by preventing and controlling new pollutions, there are no powers available anywhere to prevent local authorities or industrial firms dumping any waste materials into estuarial waters.

Last Friday a private member of the House of Commons presented for second reading the Clean Rivers (Estuaries and Tidal Waters) Bill, the prime purpose of which is to extend the powers of River Boards over estuarial waters. The Government—subject to its substantial amendment in certain respects—has accepted the Bill. The sponsors of the Bill admit the necessity for amendment. For, as at present drawn up, the Bill places much of the coastline far from any estuary under the surveillance of River Boards, an extension of their powers which would not be acceptable to other authorities concerned. The reason for assigning such wide powers to the Boards lies in the difficulty of finding a satisfactory legal definition of an estuary. Very possibly the amended Bill will apply only to selected estuaries to be listed in a schedule to the Bill, which will also define the seaward limits of each estuary. The important point, however, is that the Government has accepted in principle that there ought to be powers to ensure that no new pollution of estuaries occurs and that there should be some limited powers to abate pollution already occurring. It has become important that all who may be affected by the terms of the Bill should watch to see how it is amended.

In our own view, the state of a number of estuaries has become already so serious that stronger powers than it is proposed to give the Boards under the Bill would be well justified. But, of course, it is necessary to bear in mind that evils that have long existed cannot be quickly allayed without doing injustice to some people. A large number of industrial firms, for example, having effluents difficult or very costly to treat have deliberately chosen sites upon estuaries, since legislation indirectly encouraged them to go there. It would certainly be quite unfair to hold such firms up now as awful examples of industrial evil-doing and to call upon them to cease doing it forthwith. We have rather less sympathy with local authorities which dump untreated sewage straight into an estuary to the ruin of amenities that it should surely be their object to preserve. But, again, it is necessary to remember that they have been doing it for years and that rearrangement of the sewers, not to mention the construction of sewage works, must be a very costly matter. What we have in mind is some kind of Clean Rivers Bill (applying to estuaries as well as streams) comparable in strength with the Clean Air Act already on the statute book. Many industrialists, we believe, would already be willing to accept such legislation, providing that a not too stringent time-table were laid down for the cessation of pollution, and provided that special provision were made (as in the Clean Air Act) to allow for any difficulties there might be with certain effluents troublesome to treat. But would local governments and the Treasury accept it so easily ? Are the people of this country yet ready as a whole to accept the high cost which would have to be met from the National Exchequer and local rates ?

THE NAVY'S " NEW-LOOK "

The international situation and the new weapons and equipment of the second world war era have necessitated drastic changes in the strategy and tactics of the Armed Forces. But their effect on the world's navies has been revolutionary. Types of ships long-established as essential fighting units are being dispensed with. New ships are being built which bear no resemblance to the type of vessels they are replacing. The first to go has been the battleship. Though the United States still keeps her wartime battleships in reserve, Britain's last remaining battleship—the 44,500-ton " Vanguard," completed in 1946, at a cost of £9,000,000—will shortly be broken up for scrap. In the days of sail the battleship was called a ship-of-the-line, and since the beginning of naval history she has been the vessel on which all other surface warships have relied for support. She was designed to fight the most powerful surface ship, both offensively and defensively, which a potential enemy could employ to gain and maintain control of the sea routes. Both now, however, and as far as can be foreseen for many years ahead, our only possible potential enemy is Russia, a country which is in no way dependent on supplies from overseas. Indeed, it is quite clear from the types and numbers of ships in the Soviet Navy—cruisers, destroyers, submarines and long-range shore-based aircraft—that Russia would make no attempt to gain and maintain control of the sea routes. But her ships would do their utmost to prevent an enemy using them. It is thus a waste of manpower and resources for the Royal Navy to have ships ten times more powerful than are required to fight a cruiser—the most powerful ship of the Soviet Navy. Moreover, in the Pacific operations in World War II, aircraft from carriers were used as the main offensive weapon and naval actions were fought with the opposing battle fleets 200 miles apart. Under modern conditions, in fact, the aircraft carrier has become the most important unit of a Fleet.

Though a carrier may require cruiser protection against cruiser attack, her greater dangers to-day are from the nuclear-powered submarine and the bomber with supersonic speed. It is for this reason, and because there are no battle fleets, that we shall soon also see the last of another type of ship—the destroyer—which did such magnificent work in the two world wars. Her appearance on the seas was due to a threat from the French. In the 'eighties there was great alarm in this country because the French were building small torpedo-boats which, with their torpedoes, were to blow the battleship out of the water—the battleship whose guns had for centuries been the final arbiter of battles at sea. The Royal Navy at once countered by building the larger and more seaworthy " torpedo-boat destroyer "—to give her her full name. The latter in time soon entirely replaced the torpedo-boat as a real and effective threat to the battleship, both by day and night. At night, destroyers used darkness as a cover for surprise attacks on the enemy battle fleet. By day, flotillas of destroyers attacked the enemy battle fleet from different directions—firing their torpedoes at the closest practicable range—while it was engaged by the guns

of their own battle fleet. The torpedoes were difficult to avoid without upsetting the line of battle and disorganising gunfire. The opposing destroyers did their best to prevent these attacks and for this purpose the destroyer was also given a powerful gun armament of 4in guns. Still more guns were found necessary and the destroyer increased in size to about 2000 tons. Indeed, vessels of this kind completed for the Royal Navy after the war have a displacement of 2600 tons. For a long time the Admiralty refused to call them destroyers—they were designated "Daring class ships," after the name ship of their class. To-day, the torpedo threat comes from under water and from the air. The carrier has to be escorted by vessels which can proceed for long periods at high speed, deploy a powerful anti-submarine armament and carry a large number of anti-aircraft guided missiles as well as the complicated and extensive installations required to guide them to their targets. This cannot be done on a displacement of 2000 or even 2600 tons, and both Britain and the United States are now building fleet escort vessels with guided missiles which, from the scale model, appear to be in the region of 5000 tons. Thus, we are approaching ships of cruiser size, and they will be larger still when they have nuclear power plants. For merchant ships, anti-submarine protection is more important than protection from shore-based aircraft. For this purpose the Royal Navy has built or is building seventy-seven fast frigates with a powerful anti-submarine armament and large endurance—a figure which includes thirty-three wartime destroyers converted to frigates. In brief, the handy, "maid-of-all-work" destroyer is being replaced by the relatively large anti-aircraft fleet escort vessel and by the small, fast frigate of about 2000 tons for the protection of merchant ships.

The cruiser of the future may well also add to the Navy's "new-look." Her task of controlling the sea routes has now largely been taken over by the carrier, whose aircraft can watch over a vast area of the sea. But she may still be needed to protect the carrier and to identify and deal with suspicious vessels reported by aircraft. Britain's ten remaining wartime cruisers must soon be replaced by a squadron of some four powerful ships to supplement the three modern "Tiger" class vessels. By providing these new ships with both guns and the naval "Polaris" ballistic rocket, they might well provide a cheaper, equally effective and much safer deterrent in the missile era than the land-based rocket with its costly underground site. Last, but not least, the underwater vessel has now an entirely new look. Instead of a submarine which dives only when necessary, she has become a true submersible which is as fast and as manœuvrable as a fast surface ship and will only be found on the surface when returning to harbour. With her whale-shaped hull and with her hydroplanes transferred to a conning tower that now looks like a sail, she is barely recognisable as the submarine we have known for the past sixty years.

MORAL DIGNITY OF PLEASURE

At a period when engineering employers are disputing with unions whether the working week should be reduced from forty-four to forty-two and a half hours or to even less, and when everyone knows that actual hours worked are nearer to forty-seven it was amusing to hear Lord Chandos at the annual dinner of the Royal Society last Monday forecasting that soon after the end of this century all our needs could be provided by a working force of about 10,000,000 people each of whom would be obliged to retire on reaching the advanced age of thirty-five. Alternatively 24,000,000 people could be kept at work so long as they were restricted to a sixteen-hour week! What especially tickled us about his speech was his remark that "we shall have at some time or other to debunk work as the touchstone of respectability." We too have written something of the same kind several times since the war, though never with so much wit. We have stressed, for example, that the expenditure of capital upon the expansion of people's pleasures—as, for example, by the building of a motorway to Brighton—is just as valuable and morally justifiable as its expenditure upon something which will allow people to do more work, or to produce more goods, or to earn more money. For it is surely an out-of-date idea that we ought to feel a twinge of conscience whenever we indulge in any pleasurable activity. But if that idea is not already out of date then if Lord Chandos is right (and he very well may be) it soon will be! To quote from his speech "In this society productive work, in the sense in which we now use the words, when not required, would unbalance the economy, deflate the currency, depress land values, lead to wasteful surpluses, lead to Parliamentary questions and all the rest of it." Far from being morally right, "to work when not required will be a crime!" Lord Chandos used the argument, quite seriously, to urge the Society to stir up the Government, institutions, and firms and other organisations to pay more attention to, and perhaps, to subsidise the arts. Clearly the old moral tale of the ant and the grasshopper needs revision. In future it is the moral virtues of the music-loving grasshopper which we shall be expected to impress on our children by contrast with the shameless industry of the ant!

The Engineer—100 Years Ago (DECEMBER 2, 1859)

"The Way they do it in France"

"At Cail's large locomotive works, on the Quay de Billy, the force of draughtsmen is formidable indeed. No less than eighty-two *dessinateurs*—gentlemen of the drawing-board and dividers—were keeping up the appearance of employment at the time of our visit. Whether or not that employment consisted in copying each other's drawings we cannot say, but from what we learned as to the scale of remuneration prevailing in the profession (or whatever it may be) we should judge that the cost of reproducing a few thousand copies of an elevation of the inevitable Crampton engine would not, if the work were done by the 'staff' of the establishment, much exceed the cost of lithography. But then again, your French draughtsman is so very slow that we may be all wrong in our calculation.

"There were sixteen *artistes* in the same line at the La Chapelle workshops of the Northern Railway; and in the *bureau* of the lamented Polonceau—at the Ivry workshops of the Orleans Railway—eighteen of the fraternity supported the artistic dignity of the premises. We were given a series of lithographed sheets, on which all the five hundred locomotives on the line were classified in full, and their dimensions in bewildering detail. Fancy Mr. Gooch or Mr. M'Connell giving such information in such a shape, to visitors. Yet we saw little among the antiquated looking engines at Ivry to encourage us to undertake the translation of their interminable metres, centimetres, and millimetres into good old English feet and inches. We might enlarge upon the subject, but we are inclined to think that English mechanics will take our word when we say that French locomotives are inferior in design and workmanship to our own."

St. Lawrence River Development

X—The St. Lawrence Power Station

One power station has been built to exploit the hydro-electric resources of the International Rapids section of the St. Lawrence river. This enormous structure is two-thirds of a mile in length, and has a maximum capacity of 1880MW. The international boundary divides the power station into two, sixteen of the thirty-two generating sets being in each country.

THE St. Lawrence power station, although physically one structure, really consists of two dams and two power houses, for the U.S. section was designed and built by the U.S. power agency using U.S. contractors, and similarly the Canadian section was built by the Canadian power agency using Canadian contractors. The station is thus called the Robert H. Saunders–St. Lawrence Generating Station where it lies in Canada, and the Robert Moses Power Dam where it lies in the U.S. It is probably the key structure in the whole of the Seaway projects, and is certainly the most expensive single work of the whole concept. In design it is a straightforward low-head power station. But in size it is at present equalled by few other hydro-electric power stations throughout the world. The uniqueness of the St. Lawrence river as a source of power is well brought out by referring back to Table V in Part I of this series where three other power stations of comparable size are listed, all on this river. Apart from these, we can recall, without extensive research, only four other hydro-electric power stations, two in the U.S. and two in Russia, of greater magnitude which are in use to-day, although there are half-a-dozen or so of this order of size under construction or planned in various parts of the world.

The St. Lawrence power station is, in many respects, not unlike the Beauharnois power station described in Part VI of this series. Indeed it was remarkable to find a power scheme planned on the scale of the St. Lawrence itself as long as thirty years ago. But development of that scheme, as we explained, has only now reached almost to completion. Such is the rate of growth of electrical loads to-day, however, that the St. Lawrence power station has been built almost within the four-and-a-half-year period which the rest of the Seaway works have taken, since the final plant installations will be completed in less than six years from the start of construction.

The power station is shown in cross-section in Fig. 35. Its place in relation to the other works of the International Rapids section was shown in Fig. 31 published last week. The U.S. and Canadian halves of the structure are almost identical and may be distinguished principally by the different firms concerned with construction and the supply of plant, and some differing constructional methods and minor detail in design.

The principal generating data may be summarised as follows. The average operating head is 83ft, and there are thirty-two generating sets installed, each of 51·25MW nominal capacity. The rated flow through one of these sets is 9500 cusecs, and the average load factor 95 per cent. Thus the full-load rated flow through each sixteen-set station is 152,000 cusecs. The mean river flow is 241,000 cusecs, but at least 205,000 cusecs is maintained by the regulating works throughout the autumn and winter months when load demands are highest. The firm power output is thus 640MW for each station. Generation of power is at 13·8kV, 60 c/s, three-phase, the operating speed of the sets being 94·7 r.p.m.

The generating sets are powered by fixed-blade propeller turbines, the large number

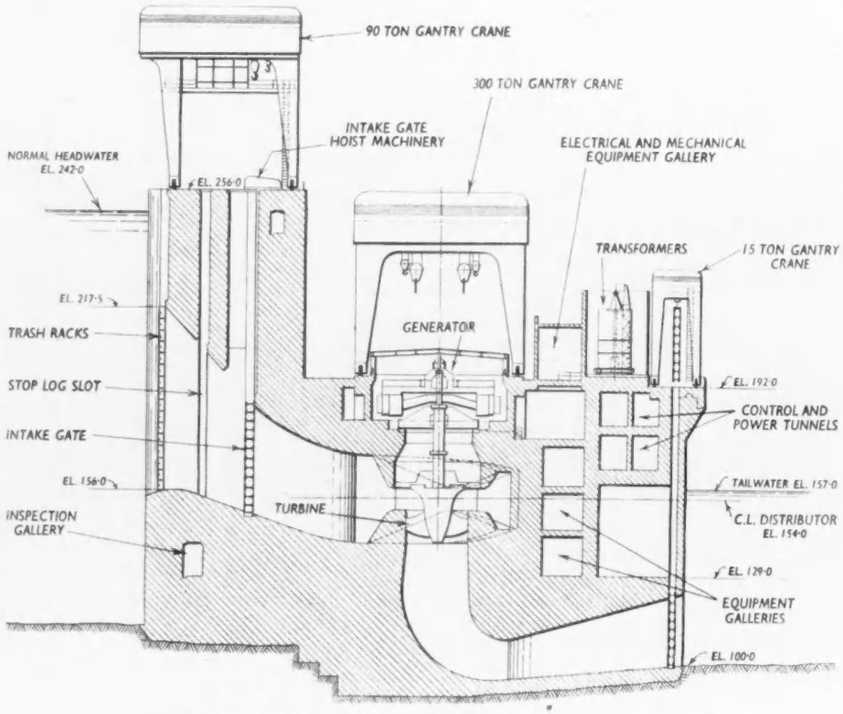


Fig. 35—Typical section through the St. Lawrence generating station

of machines and the constant head rendering the adjustable-bladed Kaplan machines unnecessary. Another point of interest is that the station is "semi-outdoor." That is, there is no machine hall; each generator is enclosed by a roof, covering a square opening, and at each end of the power house there is a servicing bay, which is enclosed as a normal building except there is no end wall but instead a rolling door. Each half of the row of sets is serviced by a large gantry crane, which can be weather-proofed by roller screen walls when it is in position over a generator, and the roof cover of the generator has to be removed. Alternatively, the gantry crane can be moved into the servicing bay.

Spillway discharges from the power pool are controlled at the crest gates of Long Sault dam, but, in addition, a measure of control is provided at the power station by weirs controlled by drum gates. There are two drum gates in the centre, each 50ft in width, and two 75ft wide drum gates at each end of the power house. Each of these six drum gates operates on a depth of 3ft to 4ft, but has a sill level of 229, and a crest at deck level, viz. 256. The principal reason for this gate installation is to flush ice downstream.

Power Station Cofferdams

The first stage of construction of the power house called for a cofferdam between Barnhart and Sheek islands, 2½ miles above the power station site, to divert the river flow to the Sault channels as explained last week. Then a cofferdam consisting of a long line of circular steel-sheet-piled cells was built in the slack water at the power station site, on the downstream side. The entire area between these two cofferdams was then dewatered. Thus a vast area of the river bed on the upstream side of the power house was dry, so easing problems of access and plant layout during construction.

The cellular cofferdam was an unusually large example of this type of construction, and is worth describing in a little more detail. It was built 500ft downstream from and parallel with the centre line of the power house sets and spanned the north channel from the tip of Barnhart Island to the Canadian mainland. The developed length was some 4300ft and in height the cofferdam reached a maximum of almost 60ft. It consisted of sixty circular cells each 64ft 5½in in diameter, connected at both upstream and downstream faces by sheet pile diaphragms and loaded with fill. To form the cells, a floating template was placed on the water and the steel sheet piling threaded and driven around its perimeter. Construction was from both ends, enabling the fill to be hauled by truck and dumped directly into the cells. Closure of the two arms was effected almost at the middle of the river channel. The height of the cofferdam was nearly 30ft above normal water levels, and was dictated by winter levels under ice conditions. Six sheet piling baffles were also constructed normal to the cofferdam to reduce scour on the toe fill.

The top of the cofferdam was graded and surfaced to provide an access road during construction. In its construction, 11,900 tons of interlocking steel sheet piling and 394,000 cubic yards of cell fill were used, together with some 126,000 cubic yards of fill materials for use as filter berm and toe fill. Construction commenced in the late fall of 1954 and closure was effected in May of 1955.

Power Station Construction

The power house itself is built on good rock foundations and its construction was characterised by massiveness and speed of progress. All of this work was, in effect, two separate construction projects going on side by side.

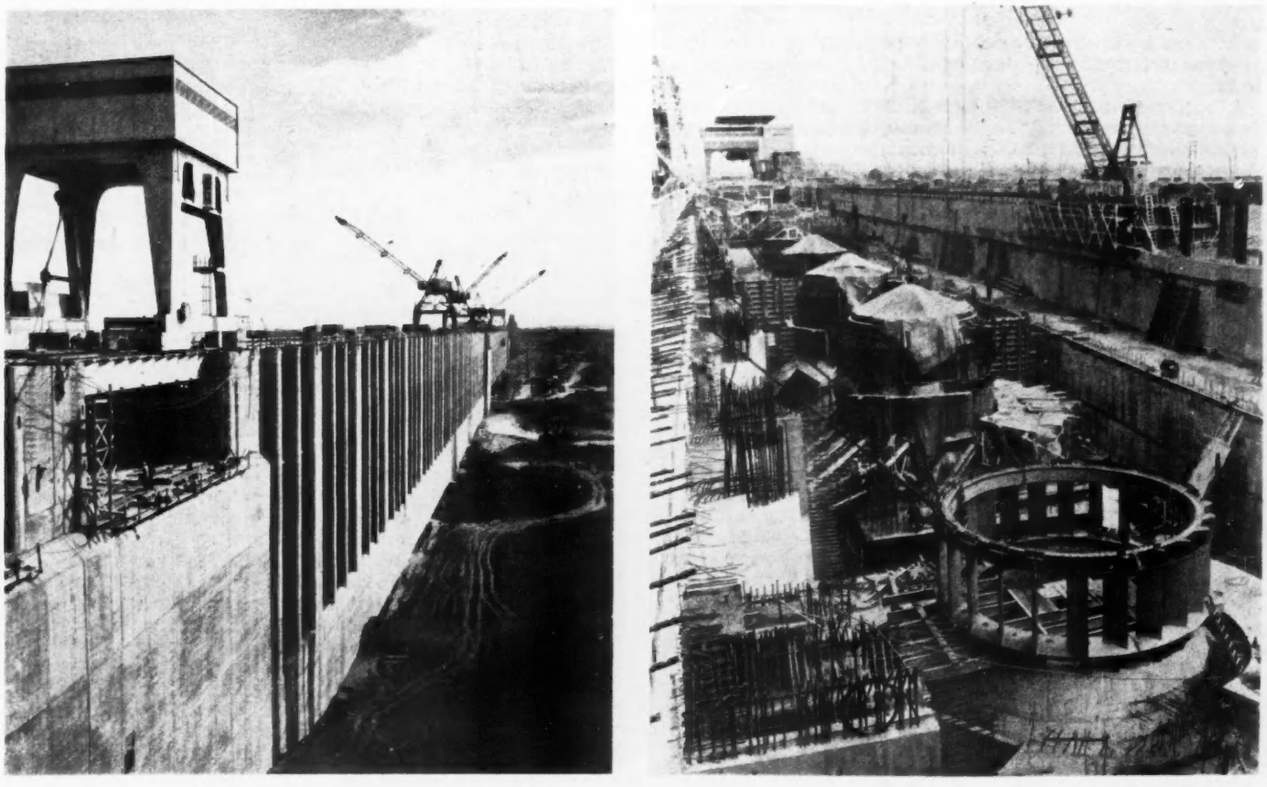
A good idea of the character of the work is given by Figs. 36 and 37. The dam wall on the upstream side entailed the emplacement of vast quantities of mass concrete and the total quantity of concrete in the power house is around 2,000,000 cubic yards. The rate of concreting reached about 65,000 cubic yards per month in each of the national "halves" of the scheme at their respective peak periods.

Variations in methods of concreting in the two "halves" are instructive. The basic requirements for mix design were primarily the same, the main differences being in the exterior concrete. The Americans used 6in maximum size aggregate as compared with 3in maximum sized aggregate used by the Canadians.

The Americans used a blend of Portland and natural cement for interior concrete, while the Canadians used an all-Portland mix, except that in special cases where heat reduction for shrinkage control was considered imperative they used fly ash as a partial cement replacement. The Americans specified and used Type 11 cement, while the Canadians used the "Canadian Standard" cement, which is comparable with the U.S. Type 1.

All transport of concrete on the American side was by bucket or dumper, and conveyor belts were not permitted. On the Canadian side, conveyor belts were used for transporting concrete. In general, all mass concrete on the American side was limited to 5ft lifts while on the Canadian side lifts were permitted up to 35ft. The Americans used steel forms, the Canadians used timber. The Americans used horizontal joints with no waterstops; the Canadians used 8in keyways and horizontal waterstops.

The maximum lift on the Canadian side



Figs. 36 and 37—Constructional views of the St. Lawrence River generating station. (Left) The station from upstream, showing the constructional cranes, head gate gantry and one of the drum gate openings. (Right) The substructure at turbine level, with a speed ring in position on the draught tube in the foreground, and further back, pit liner assemblies in position

was in fact 36ft. The use of these very high lifts follows a technique which has been developed quite extensively by the Hydro-Electric Power Commission of Ontario. The specifications call for a limiting rate of pour of 2ft per hour, or 2ft 6in during the summer. In the case of the 36ft pour just mentioned, the total volume was about 760 cubic yards, in a region which was heavily reinforced, the largest reinforcement being 1¼in diameter deformed bars. The slump of the concrete was specified to be not more than 4in and the maximum w/c ratio 0·57 (average 0·54). An air-entraining agent (" Protex ") was used to the extent of 5 per cent. In these heavily reinforced pours, the maximum aggregate size was 1½in, the 3in aggregate being used only for the mass concrete, where slump was kept to 2in to 2½in, and where a maximum yardage of concrete of 3300 was placed in one operation.

The timber forms for this concreting in the Canadian sector were made from 4ft by 8ft waterproof plywood panels, carried by double 4in by 12in walings and soldiers. Concrete was brought to the form in 4 cubic yard skips, and placed through hoppers at the top of the form, from which elephant trunks distributed it. The advantages claimed for the method are the speed of construction it allows and the fact that less construction joints and hence less water seals are needed.

Each generating set in the power house takes up a width of 80ft. This width was split into four parts for concreting in the Canadian power house with construction joints between them. The fly ash concrete (up to 25 per cent fly ash) was used in the roofs of the scroll casings, where shrinkage could not be tolerated, and also in the beams over the drum gates at the ice sluices. For winter concreting, the shutters were insulated with glass fibre, with steam heating inside them prior to concreting and also steam heating in the water and the sand in the coldest weather. Generally, a temperature of 60 deg. was maintained in the concrete. The boiler plant needed for heating consisted of three 250 h.p. and one 125 h.p. boilers.

A feature of the concreting work on the Canadian power house was the checking carried out by a site concrete laboratory. Control charts showing, for all the concrete placed, w/c, seven- and twenty-eight-day strengths, and " *s* " the coefficient of variation of these strengths, were kept.

Power Station Equipment

Apart from the relative novelty of the semi-outdoor layout, details of the power house design follow normal present-day practice fairly closely.

The nominal rating of each alternator is 60MVA, 13·8kV three-phase, 60 c/s, 94·7 r.p.m. and 0·95 power factor. On the Canadian side* there are four main transformers, each one taking the output of four sets, and capable of taking 15 per cent over the rated output of the group of four without serious overloading. The transformers are situated alongside the sets, as shown in the drawing. Each transformer consists of three single-phase elements, each of 86MVA and 13·5–13·5/132kV delta-delta/earthed star connected, giving a bank ratio of 13·5–13·5/230kV.

The positioning of the transformers gives short low-voltage connections ; power is taken from each transformer through an oil-filled 230kV cable to the switching and transformer station which is about 2 miles from the power station. Power station control is from a central control room (again in duplicate, with one control room at the U.S. and one at the Canadian shore). The control and metering equipment and the station auxiliaries follow conventionally accepted practice for a large modern power station. The following notes on protection and on the transformer station have been reproduced respectively from the papers of Messrs. Fullerton and Matheson.

"Since there are no high-voltage circuit-breakers at the generating station end of the transmission circuits to the St. Lawrence transformer station, remote tripping circuits are provided to operate 230kV circuit-breakers at the transformer station end of the lines for transformer, line or bus faults.

"The main protection for the 230kV circuits to the St. Lawrence transformer station is by wire-pilot relays at both ends of the circuits. Back-up protection at the transformer station end is provided by directional over-current relays for phase and ground faults. At the generating station end the transformer back-up protection serves also as back-up protection for the 230kV circuits.

"Differential protection, phase and ground back-up protection, and gas-detector relays are provided for the four 258MVA transformer banks. The 14·4kV bus is protected by differential and ground relays. Induction over-current relays protect the 3000kVA station service transformers.

"The sixteen 60,000kVA generators are protected by differential split-phase, phase current balance, stator ground, and phase back-up relay protection. In addition, devices used to detect mechanical failures will operate to shut down the generator affected. These include : low governor oil pressure ; overspeed ; incomplete starting sequence ; high thrust bearing temperature.

"A complete system of annunciators and alarms is provided to monitor the above protections and other abnormal conditions.

"The transformer station has been designed for expansion to an ultimate capacity consisting of four auto-transformers, four step-down transformers, two regulating transformers, seventeen 230kV lines, sixteen 115kV lines, and twelve 44kV feeders.

"Airblast circuit breakers with an interrupting capacity of 15,000MVA are installed in the 230V switchyard. The bus arrangement features 1½ breakers per element and fourteen breakers are scheduled for service by 1959. The switch structures and equipment are designed for 900kV B.I.L., with 196kV insulation class. Each breaker is equipped with two motor-operated isolating switches.

"Each 230kV outgoing line terminal is equipped with a gang motor-operated 1200A disconnecting switch with three-pole manually-operated grounding switch, three potential coupling capacitors, power line carrier and communication equipment.

"Airblast circuit breakers of a 'dead' tank design having an interrupting capacity of 5000MVA have been installed in the 115kV switchyard. A total of nine will be in service by 1959. The bus arrangement gives 1½ breakers per element. The design is for 550kV B.I.L. with 115kV insulation class, except disconnecting switches, which are 138kV. The outgoing lines are equipped with potential transformers.

"By 1959, there will be in service two 115MVA, 230-115-13kV, auto-transformers ; two 25/41MVA., 115-44kV stepdown transformers, and one regulating transformer, installed in the 230kV tie line to the Power Authority of the State of New York. This regulating transformer will have a capacity of 250MVA with an operating range of 248/230kV, and is equipped with an on-load tap changer. It is protected by lightning arresters. Cascade type potential transformers and high accuracy current transformers will be installed for metering on the tie line."

The Canadians have achieved a much cleaner installation of switchgear and high tension lines than on the U.S. side, which appears to be due to the fact that there is a multiplicity of local power companies using power from the station on the U.S. side, but only the " Ontario Hydro " on the Canadian.

Each turbine intake is divided into three openings, each one of which is 17ft wide by 37ft high and can be closed by a gate.

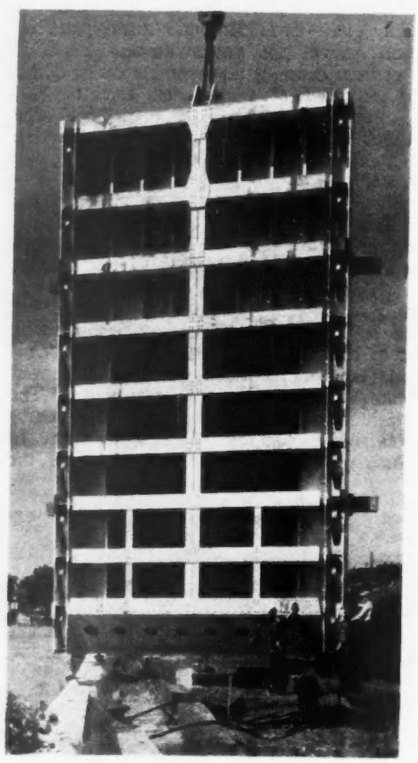


Fig. 38—Turbine intake gate. There are three such gates at each intake

One of the gates is illustrated in Fig. 38. With 83ft head on the sill, the water load on the gate is 3,000,000 lb. These gates weigh about 40 tons each, and were delivered to the site complete. They are handled by two 90-ton gantry cranes. The tail-race gates are handled by two 15-ton gantry cranes, and the main sets, as already mentioned, by two 300-ton gantry cranes. The gantry crane installation follows the division of the station into its two " national " halves, but is of interest because only two gantries have been installed for each duty, even though the station is so large. Each gantry is capable of working over the entire length of the station, and specifications are identical so that the whole station can be serviced even though one gantry is out of use. The 300-ton gantry cranes are, in fact, critical to the success of the semi-outdoor design, and should be explained in greater detail. The following explanation refers specifically to the Canadian machine,

* For more detailed information on the electrical plant of the Canadian station see *The Engineering Journal* (Engineering Institute of Canada), September, 1958, " Electrical Features of the Robert H. Saunders-St. Lawrence Generating Station," by R. M. Fullerton ; " The St. Lawrence Transformer Station," by A. Matheson ; and " Design of 230kV Transmission Lines," by N. J. McMurtrie.

Fig. 39—300-ton gantry crane serving the semi-outdoor power house

illustrated in Fig. 39, but the U.S. one is essentially similar.

300-Ton Gantry Crane

Successful operation of the power house plant is very dependent on the performance of the two gantry cranes, the specifications for which thus make certain rather stringent demands.

Fast travelling and hook speeds were called for, and especially very accurate characteristics in "spotting" a load and in lowering it. In contrast to many crane duties, lowering is more critical in this case than hoisting—for instance in lowering a turbine runner or alternator rotor into position, where clearances are very small. "Inching" control of lowering was therefore essential, together with a "spotting" accuracy of $\frac{1}{16}$in. The electrical system employed to achieve these requirements was a modified Ward-Leonard drive, with a control arrangement derived from the Canadian General Electric Company's "Maxspeed" system.†

Structurally, the crane consists of two portal frames, one above each rail track, and each one tied by a heavy beam which is mounted on the bogies. These two frames are connected laterally by four cross-members—two 12ft deep trusses between the outer faces of the portal legs, and two 42in deep "castellated" beams between the inner faces. The two heavy cross girders which carry the rails on which the crab travels are suspended below the portals by pinned links.

The reason for separating the crab girders from the main structure is to be found in the necessity for rapid working, and hence in the design of the auxiliary cranes. The two auxiliary cranes are each 15-ton jib cranes, and each one is carried on a cradle which travels suspended below one of the cross girders, on two rail tracks carried on ledges below the level of the rail for the crab. Each auxiliary crane can thus travel across the width of the enclosure, and is a full-circle machine with a radius of 11ft 6in. In addition, each of these cranes can protrude its jib through the upstream curtain wall, to put a load on to a lorry on the roadway on that side. Thus the design ensures that the gantry need not be moved except for major "lifts." But because the jibs of these cranes must protrude under the main portals, the cross girders had to be at a lower level than the portals and hence were pinned below them. The jib cranes are not counter-balanced, and the centre post of each crane takes the bending and tension due to the load.

The rolling door curtains which are used to enclose each side of the crane are each 48ft 9in wide by 37ft 6in high and are electrically operated. A servicing gantry of 13 tons capacity is mounted on the crab girders, and runs on rails outside the crab rails.

The crane was designed and built by the Dominion Bridge Company, Ltd.

Data for 300-Ton Gantry Crane

Capacity of main hoist	300 tons
Capacity of subsidiary hoists	2 by 15 tons
Deadweight of crane	600 tons
Total horsepower installed	700
Number of motors	31
Length of crane travel, erection bay to 16th set	1350ft
Lift of main hook	79ft
Travelling speed :	
Unloaded	200ft per minute
Loaded	100ft per minute
Unloaded hook speed	15ft per minute
Loaded hook speed	5ft per minute
Gauge of crane rails	53ft
Gauge of crab rails	19ft
Subsidiary hooks :	
Height of lift	92ft
Hoisting speed	60ft per minute

† For fuller description see "300-Ton Gantry Crane for the St. Lawrence Power Project," by P. Pemberton Pigott and R. D. Mutch, *The Engineering Journal*, October, 1957.

Organisation

Responsibility for the power station lies with the Hydro-Electric Power Commission of Ontario for the Canadian half, and with the Power Authority of the State of New York for the U.S. half. The former body has a tradition of designing its own hydro-electric developments, and in this case too, was directly responsible for design and for supervising construction. The U.S. body, however, appointed consulting engineers—Messrs. Uhl, Hall and Rich—to carry out these latter functions. Neither of the U.S. agencies has been concerned directly with engineering design, which has been done by the consultants just named and by the U.S. Corps of Engineers for the U.S. navigation works. By contrast both of the Canadian agencies have their own engineering staffs for design and supervision. It may also be mentioned that in Part I of this series Messrs. Uhl, Hall and Rich were stated, erroneously, to be consultants to the Seaway Development Corporation.

In addition to the four main agencies, there are two "International Supervisory Agencies" which have overseen matters of international policy as they affect the whole Seaway and Power scheme. The first of them is called the International Joint Commission, and the second the St. Lawrence River Joint Board of Engineers.

(To be continued)

Dry Cooling Towers and Jet Condensing Plant

In the "dry cooling tower" system described here the exhaust steam from turbines gives up heat to cooling water sprayed into a jet condenser. Part of the resulting mixture of condensate and cooling water returns through the feed heating system to the boiler. The rest is pumped through finned cooling elements arranged in a cylindrical stack round the base of the cooling tower to reject heat to atmosphere. The closed circuit eliminates the evaporative loss associated with ordinary "wet" cooling towers and dispenses with the need for make-up water. This "dry" cooling system is being developed in Great Britain by The English Electric Company, Ltd., and is being applied to one of the five 120MW turbo-alternators in the Rugeley power station of the Central Electricity Generating Board.

A "DRY COOLING TOWER" system is being developed for large-scale power installations by The English Electric Company, Ltd. It is based on a concept that was first propounded by Professor L. Heller and Mr. L. Forgo of Budapest, and described in papers at meetings of the World Power conference in 1956 and 1960. The idea of the "dry cooling tower" system is that turbine exhaust steam is condensed in a spray condenser using feed water in a closed circuit, the final rejection of heat to atmosphere being effected in specially designed finned tubular coolers. The use of a closed circuit for the water eliminates the loss by evaporation which is inherent in the orthodox wet cooling tower system. Hitherto the need for make-up water supplies has been a major consideration in the siting of power stations near rivers, lakes or estuaries. With the Heller system this limitation vanishes and the choice of site can be governed rather by proximity to load centres and accessibility of fuel supplies. At the same time the economic application of steam power plant can be extended to areas where scarcity of cooling water has tended to make steam generation impracticable.

There is a choice of two main forms of dry cooling tower. One (Fig. 1) relies upon natural draught for the flow of air over the finned coolers; the other uses induced draught fans and a diffuser in the cooling tower to augment the flow of air.

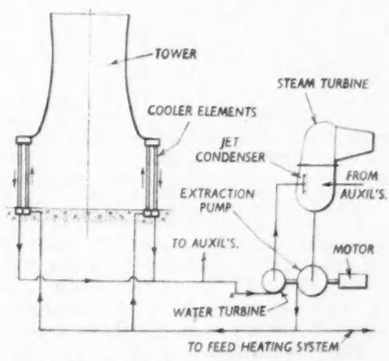
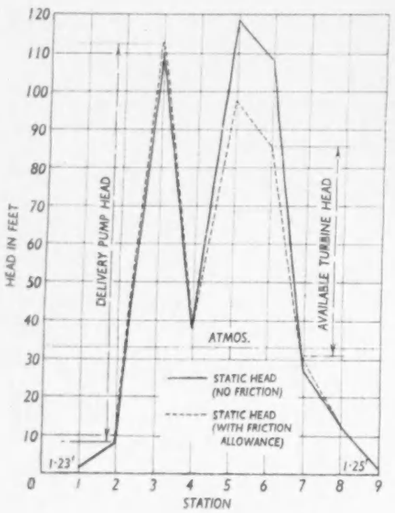


Fig. 1—Schematic diagram of dry cooling tower condensing system using natural draught

Factors such as fuel costs, atmospheric conditions and the output of the generating plant will influence the choice.

In both cases the cooling water system is the same. Water of condensate purity is sprayed into the jet condenser to condense the exhaust steam. An extraction pump withdraws the mixture of condensate and cooling water from the condenser. Part of this water is taken through the feed heating system back to the boiler in the normal way. The rest is pumped through the specially designed cooling elements which form a cylindrical stack around the base of the tower. Air passing over the finned surface of these elements cools the water, which is then returned through a water turbine to the spray condenser jets.

The introduction of the water turbine is interesting: its origin is as follows. To



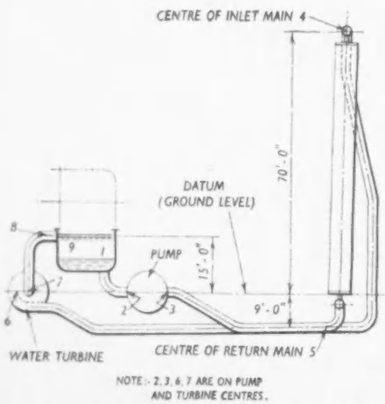


Fig. 2—Static head diagram for a typical 120MW dry cooling tower installation

prevent leakage of air into the cooling water system the pressure of the latter is kept above atmospheric pressure throughout the circuit. It follows that the pressure differential between the top of the cooler (which would otherwise be sub-atmospheric) and the condenser is greater than would otherwise be necessary. To take advantage of this excess head it is desirable to include a Francis turbine which can conveniently be coupled to the extraction pump or extraction pump motor, as indicated in the diagram (Fig. 1). In this way about 90 per cent of the excess head can be recovered as indicated in Fig. 2 which applies to a typical 120MW installation.

Examples of the Heller cooler elements which form the basis of the whole system are illustrated in Figs. 3 and 4. Aluminium is used throughout and a cooler consists of a number of standard elements, each 16ft high by 8ft wide. Each element consists of up to eight rows of tubes, each row con-

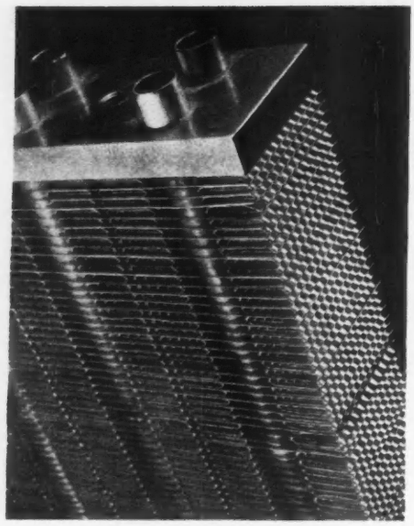


Fig. 3—Two-row cooler elements

taining forty tubes. A two-row element is shown in Fig. 3.

The construction is shown in greater detail in Fig. 4. Slotted aluminium strips spaced apart by circular collars are threaded on to each aluminium tube. In this assembly tight contact between the surfaces is essential. It is achieved by expanding the tubes into the collars while the collars and strips are being subjected to longitudinal pressure through the medium of end plates. Finally the tubes are expanded into the end plates without requiring soldering, brazing or welding.

Whether these coolers are used in forced draught or natural draught cooling towers, the efficacy of the system depends upon the achievement of good heat transfer with small temperature differences and small pressure losses on the air side of the cooler element. A heat transfer coefficient of 80–120 kcal per square metre-hour-deg. Cent. is claimed for strip-finned surfaces of the kind described here. The purpose of the slots is to inhibit the boundary layer that would build up with an air flow along an equivalent plane surface and would reduce the heat transfer per unit area.

The number and arrangement of the cooler elements would differ considerably for different applications, being largely dependent on economic factors. For example, small turbo-generator sets of about 5MW output would normally use an induced draught arrangement, the cooler being formed in a circle or rectangle of the height of a single element, i.e. 16ft. On the other hand, above about 20MW output a natural draught arrangement is usually more economic, and at 100MW the cooler would generally be three elements, or 48ft in height. The number of tube rows in depth is unlikely to exceed six for the natural draught case, but may be eight or even ten where induced draught is used.

In the scheme shown diagrammatically in Fig. 1 there are two passes on the water side so that both inlet and outlet branches are at the base of the coolers. In some installations, however, a single pass arrangement may be used, the water entering at the top and leaving at the base of the cooler.

To simplify maintenance and provide a safeguard against freezing the coolers are grouped in sections, each of which can be drained by gravity into a tank within the base area of the tower. This facility can be used during part load operation. With induced draught plant, however, it would be more convenient to run the fans at reduced speed during part load conditions or at low ambient temperatures.

The use of a spray condenser avoids the temperature drop inherent in a tubular condenser and results in an improved vacuum; there is also a substantial reduction in depth below the turbine casing and a consequent saving in civil engineering costs.

The condenser shell is fabricated in steel. The water from the coolers flows through the Francis turbine and through ducts along the condenser shell. Jets, screwed into these ducts are disposed in such a way as to spray against the flow of steam and thereby produce maximum mixing. Another set of nozzles in the condenser sprays water return-

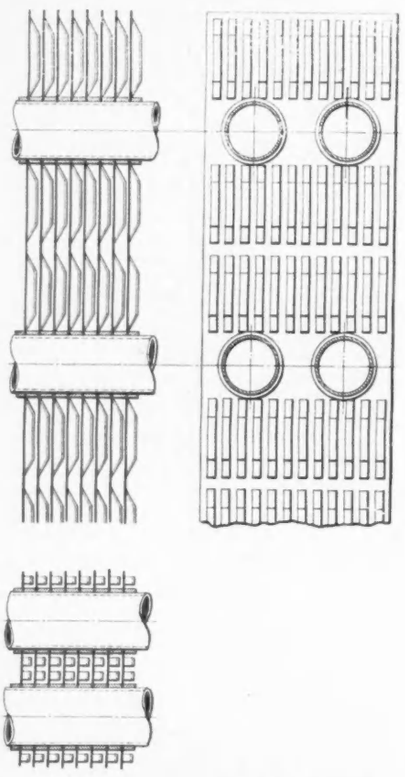


Fig. 4—Detail of cooling element showing fins, tubes and spacing rings

ing from cooling the plant auxiliaries. Any gases not condensed can be removed either by steam jet air ejectors or by air pumps such as rotary Leblanc pumps.

The condenser casing is bolted directly to the turbine exhaust flange and is supported on adjustable spring feet which take up expansion, with the help of expansion pieces fitted as necessary in the main connecting pipes. The condenser shell houses a number of horizontal pipes into which are screwed specially designed nozzles. These nozzles project the cooling water in the form of a finely divided spray.

In an induced draught installation the "tower" is, essentially, no more than a framework to support the coolers and the diffuser if one is used; the structural

material can be wood, steel or reinforced concrete. A typical induced draught cooling tower for a 5MW installation incorporating diffusers (to reduce the exit air velocity and the fan loading) might consist of three vertical spindle fans arranged in line in a rectangular structure 100ft long by 45ft wide by 25ft high, excluding the diffuser above each fan.

In a natural draught installation the tower would support the coolers and serve as a chimney. Typical dimensions for a tower for a 120MW set would be cooler diameter, 350ft ; height, 350ft ; throat diameter, 200ft. In appearance the tower would be not unlike a conventional natural draught " wet " cooling tower made of reinforced concrete.

Typical examples of (approximate) dimensions of natural draught dry cooling towers designed for " European climatic conditions" are tabulated below.*

Typical Dimensions of Natural Draught Dry Cooling Towers

Output, MW	50	75	100
Diameter of base, m ...	70	70	80
Diameter of base, ft ...	236	236	270
Overall height, m	55	80	80
Overall height, ft	186	270	270

The first large-scale commercial application of this system is now being erected at Rugeley power station. This installation serves a 120MW turbo-generator set which will be alongside four similar sets working with the conventional " wet " cooling system. This installation has been ordered by the C.E.G.B. to gain experience.

Multi-System Electric Locomotives

Two reports on the design of locomotives and motor coaches for operation on two or more electrical supply systems are being presented to the session of the International Railway Congress Association in New Delhi which is being held this month. Requirements for motive power of this kind are increasing with the extension of main-line electrification and the linking-up of sections which previously were isolated. We summarise below the principal trends of practice revealed in the reports.

WHEN the first locomotives were ordered for service on the French National Railways industrial-frequency electrification in the Savoy, it was a requirement that they should be able to operate on 1500V d.c. as well as on a high-voltage a.c. supply. This was made necessary by the situation of the line on which they were to work, namely, the branch from Aix-les-Bains, on the Culoz–Modane 1500V d.c. electrified section, to La Roche-sur-Foron. Through coaches to Annecy and beyond are detached in the main-line platform at Aix-les-Bains, under the 1500V catenary, and the branch line locomotives had to be capable of leaving and entering this platform with moderate loads, as well as of running light over a few miles of the d.c. section to the electrical maintenance depot at Chambéry.

Since that time the extension of a.c. railway electrification at industrial frequencies in France and elsewhere has greatly multiplied the number of places where different electrification systems converge, and the question of equipping locomotives for running on two or more systems is no longer one primarily of convenience for local movements, but now affects the operation of long distance trains. Multi-system locomotives were therefore an appropriate choice for one of the questions to be discussed this month at the enlarged meeting in New Delhi of the Permanent Commission of the International Railway Congress Association. Two reports have been prepared on the subject, one by K. von Meyenburg of the Swiss Federal Railways, presenting information from Austria, Belgium, France, Italy and Switzerland ; and the other by J. J. Jonker of the Netherlands Railways, dealing with Great Britain, Germany, Japan, the Netherlands and the U.S.S.R.

Both reports mention one instance of dual-voltage d.c. rolling stock, namely the twelve 3000V/1500V two-coach sets used for through express services between Brussels and Amsterdam, but they are concerned in general with locomotives for inter-running between a.c. and d.c. systems, or between two different a.c. systems. The two reports contain copious tabulated information on motive power in these categories already in service or under construction, accompanied by the reporters' observations on the methods adopted in the countries with which they have dealt. In the following paragraphs we summarise some of this information under the headings of the countries responsible for the various lines of development.

France

Thirteen multi-system locomotives are already in service on the French National Railways. Nine of these are at work on the 25kV, 50 c/s electrification in the Savoy mentioned already. These are primarily a.c. locomotives, but for working at reduced performance on d.c. are equipped with a rotary-converter which supplies a.c. to the secondary of the transformer, so that the normal a.c. tap-changing control is used. On 1500V d.c. the locomotive one-hour rating is 400 h.p. at 7 m.p.h., as compared with 4200 h.p. at 40 m.p.h. on a.c.

A more recent development has been the construction of four locomotives to work on a.c. both at 25kV, 50 c/s and 15kV, 16⅔ c/s. These have been in service between Luxembourg and Basle, and at the latter station are able to run over lines electrified on the low-frequency system of the Swiss Federal Railways. Two of the locomotives have a.c. series motors, and two have d.c. motors supplied through rectifiers. The two locomotives with a.c. motors have the same rating, 4460 h.p., on both frequencies. The higher voltage drop on 50 c/s makes alteration of connections to the transformer unnecessary for working on 25kV, but changes are made automatically in the traction motor interpole shunt circuits and in the transformer tapping supplying the auxiliaries. In the rectifier locomotives also, auxiliary supply circuit changes are made, but none are necessary in the traction circuit. These locomotives are rated at 5120 h.p. on the standard-frequency and 4040 h.p. on the low-frequency supply.

Three a.c./d.c. locomotives are under construction for the French National Railways. Two of these will operate on 25kV, 50 c/s a.c. or 1500V and 3000V d.c. and will carry a rectifier equipment from which the motors will be supplied with 1500V d.c. when running on a.c. sections. A d.c. control system with provision for three motor groupings (series-parallel and parallel on a 1500V input ; series and series-parallel on 3000V) will be fitted. The third locomotive will be one of the existing " 16500 " class a.c. rectifier locomotives modified for working on 1500V d.c. with resistance control, and series-connected motors. This is a two-motor design primarily for a.c. routes and operates normally with its motors in parallel.

Switzerland

The Swiss Federal Railways have six dual-frequency (50 c/s and 16⅔ c/s) shunting locomotives in operation at Basle, four with rectifiers and d.c. motors and two with a.c. series motors. All are controlled by tappings on the transformer secondary. A locomotive is being built for shunting and goods working in the Geneva area which will operate on the same two a.c. frequencies and also on 1500V d.c., using a silicon rectifier system on a.c. and direct supply of the traction motors through control resistances with cam-operated contactors on d.c. Ten four-system shunting locomotives (1500V and 3000V d.c., 15kV and 25kV a.c.) are being built for service at Geneva and Chiasso. These, again, will be rectifier locomotives with direct supply to the traction motors via resistances on d.c., but grid control of the rectifiers will be used on a.c. in order to save the space that would be necessary for tapping contactors or a tap-changer.

French National Railways dual-frequency locomotive with a.c. series motors and control equipment for 50 c/s and 16⅔ c/s systems

The project for the four-system T.E.E.

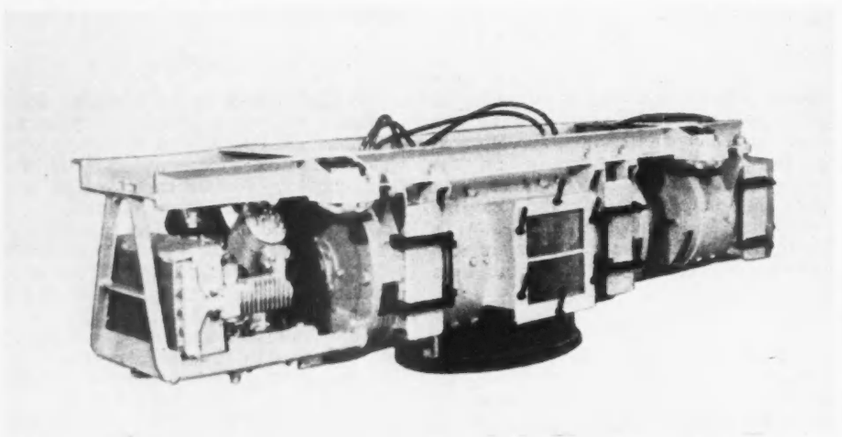
* Quoted from *Periodica Technica (Engineering)*, Volume 2, No. 4, Budapest, 62. " The Air Cooled Condensing Equipment, System Heller," by T. Jaszay.

trains was referred to in our June 5 issue, page 902, and it may be recalled that on a.c. sections the motors will be supplied through silicon rectifiers. In the driving cabs of these trains four push-buttons will be fitted for selecting the pantograph and setting up the electrical connections appropriate to the various supplies. One action by the driver will cause a pantograph to be raised, the form of supply to be verified by voltage-sensitive and frequency-sensitive relays, the appropriate power and auxiliary circuit changes to be made, and the relevant circuit-breaker to be freed for closing.

Italy and Austria

The Italian State Railways operate twelve two-car sets on routes supplied partly with 3000V d.c. and partly with three-phase a.c. at 3600V, (Milan–Genoa–Ventimiglia, Turin–Bologna, and Turin–Rome). Each consists of a motor coach with a normal 3000V d.c. equipment coupled to a trailer with three-phase pantographs and transformer-rectifier equipment for supplying 3000V d.c. to the motor coach when running on three-phase sections.

A dual-frequency ($16\frac{2}{3}$/50 c/s) mixed traffic locomotive is working on the Austrian State Railways between Vienna and Passau. This line is electrified at 15kV, $16\frac{2}{3}$ c/s, but provision has been made for the locomotive to work on 25kV, 50 c/s, in case the need to do so arises later. The locomotive is powered by four a.c. series tandem motors, each comprising two armatures and commutators in a common frame with the two twelve-pole field systems. Adjustment of the interpole fields to suit the two supply frequencies is made by changing the number of turns in circuit instead of by shunts.



Underframe-mounting auxiliary group for 1500/3000V d.c. motor coach comprising tandem-armature motor driving compressor and l.t. generator

Western Germany

Main-line electrification of the German Federal Railway is at 15kV, $16\frac{2}{3}$ c/s, but the system includes the pioneer 20kV, 50 c/s Hollental line in the Black Forest, while in future there will be connections with the French 25kV, 50 c/s system at Überherrn and near Sarrebrück. The administration is therefore having three 3180 h.p. rectifier locomotives built for operation on the two frequencies and three voltages. Control will be by tappings on the transformer primary, and some of the higher-voltage tappings will automatically be made inoperative when running on 25kV and 20kV in order to restrict the voltage applied to the rectifiers.

Great Britain

In providing information for the report by J. J. Jonker, British Railways stated their opinion that it would be necessary in future to have available locomotives able to operate at 750V from a third rail and at 25kV, 50 c/s, from an overhead system. All motive power for British Railways 50 c/s a.c. electrification comes into the terms of reference of the report since it must operate on the two a.c. voltages of 25kV and 6·25kV. Particulars are given of the motor coach stock at present running on the Colchester–Clacton–Walton section of the Eastern Region (described in our issues of April 17, April 24 and October 2) and brief reference is made to the method of initiating the circuit changes necessary for running on the two voltages by means of track magnets similar to those of the a.t.c. system.

Japan

The Japanese National Railways have in hand a large programme of electrification at 20kV, 50 c/s or 60 c/s (in different parts of the country) and there are already three transition points between this system and the existing 1500V d.c. electrification. Two dual-system motor coaches and two dual-system locomotives are being provided, all of which operate with rectifiers on a.c. and with resistance control on d.c. One of the locomotives is unusual in having three single-motor bogies, the machines in which will operate all in series or all in parallel on d.c., while on a.c. the locomotive will start in series and change to a grouping of two motors in parallel connected in series with the third, presumably in order to limit the current demand on the silicon rectifiers with which this design will be equipped. This locomotive will work on a.c. over a short line with gradients up to 1 in 40.

Further points of contact between d.c. and a.c. electrification will soon occur in Japan and the railway administration considers that where considerable traffic is handled by motor coach stock, dual-system equipment is desirable. If a few locomotive-hauled trains work on such a line it is justifiable to provide a dual-system locomotive, provided this can also be employed on goods traffic, but in general it is more economic to change locomotives when passing from one electrification system to another.

Auxiliary Services

In addition to the tabulated information on auxiliary services in both reports, that by K. von Meyenburg reviews practice in this direction. The tendency in d.c. stock is to reduce the number of machines as far as possible, and in the 1500V/3000V motor coaches on the Brussels–Amsterdam route there is a single rotary group consisting of a motor driving a generator and compressor. The motor is a tandem machine with arrangements for connecting the two armatures in series or parallel. Locomotives for two a.c. frequencies and voltages may have alternative supply tappings on the transformer, and this is the practice when all or some of the auxiliaries are fed through rectifiers, but where all are a.c. machines this may not be considered necessary. The Austrian locomotive mentioned above, for example, has a single feed to the auxiliaries, all of which are driven by a.c. series motors receiving 98V on a $16\frac{2}{3}$ c/s supply and 131V on 50 c/s.

In a.c./d.c. motive power only certain machines, such as compressors, battery-charging generators and traction-motor blowers have to operate on both forms of supply. The Swiss T.E.E. trains will have a rotary group driven by a 1500V/3000V double-commutator motor which will be supplied from the d.c. contact wire or, on a.c. sections, from semi-conductor rectifiers. In the French a.c./d.c. locomotives for the Savoy group of 50 c/s lines the auxiliaries are driven by three-phase motors operated from an Arno phase-converter. For d.c. traction, as already noted, these locomotives are equipped with a d.c./a.c. converter feeding the low-tension side of the transformer, and the Arno set therefore continues to receive a supply from the transformer in these circumstances.

Technical Report

Experiments with a Two-Dimensional Aerofoil Designed to be Free from Turbulent Boundary-Layer Separation at Small Angles of Incidence for all Mach Numbers. By D. W. Holder and R. F. Cash, of the Aerodynamics Division, N.P.L. Reports and Memoranda No. 3100. H.M. Stationery Office. Price 17s. 6d.—This investigation was designed primarily to check the validity of a simple method which had been suggested for designing an aerofoil section on which, for a limited range of incidence, turbulent boundary-layer separation is absent at all values of free-stream Mach number. Assuming that this method proved successful, a second object was to study the transonic flow past the aerofoil, and to compare the results with previous speculations concerning the nature of the flow when separation is absent. Since separation was expected to occur when the angle of incidence was increased to a sufficiently large value, a third object was to study the flow when separation was present and, in particular, to confirm whether the effects of separation are less severe for the present section than for most previous sections.

The trailing-edge angle was chosen to be 3 deg. and this was achieved on a 4 per cent thick symmetrical section without concave curvature by using a well-forward (0·2 chord) position of maximum thickness. This section was expected to give flow free from shock-induced separation at angles of incidence less than $1\frac{1}{2}$ deg., and this expectation was realised in the experiment.

It was found that, when the free-stream Mach number was raised, the shock wave on the upper surface moved back to the trailing edge before that on the lower surface. This behaviour is in contrast to that observed on previously tested sections where the effects of separation have resulted in the lower-surface shock reaching the trailing edge first with, in most cases, undesirable effects on the loading on the section. However, it was found that the boundary layer, although not separating, evidently still had significant effects on the flow, and it is considered that a full understanding must await further research, notably on the pressure distribution through a weak normal shock interacting with a flat-plate boundary layer, and on the pressure changes along wakes.

The third object of the experiment, namely, to investigate whether, when boundary-layer separation occurred, the effects were less severe on the present section than on most previous sections, was also generally successful.

A feature of the results obtained at large angles of incidence is that the flow on the major part of the lower surface appears to be relatively independent of disturbances to the trailing-edge pressure produced by the effects of flow separation on the upper surface.

"Jason" Reactors for Research and Training

On November 24 Sir John Cockcroft inaugurated "Jason," a small nuclear reactor for research and training. It is the first reactor of its kind to be commercially available in this country. Based on the "Argonaut" at the Argonne National Laboratories, U.S.A., "Jason" was designed and built in seven months by the Hawker Siddeley Nuclear Power Company, Ltd., at the company's works, Slough, Bucks. It uses enriched uranium with graphite reflectors and is cooled and moderated by light water. At the maximum power of 10kW the flux is about $1 \cdot 5 \times 10^{11}$ neutrons per square centimetre per second. A modified version of "Jason" has been ordered for installation at the Winfrith, Dorset, establishment of the United Kingdom Atomic Energy Authority. Other variants of "Jason" are envisaged, with a range of power from 1W to 20kW.

"JASON" which was officially inaugurated by Sir John Cockcroft on November 24, is a small reactor for research and training, built by the Hawker Siddeley Nuclear Power Company, Ltd., and installed at Slough, Bucks. In its original form it is a 10kW reactor and was primarily intended for research work in connection with the development of the organic moderated reactor which, it will be recalled, forms the basis of a ship propulsion system submitted by the company for consideration by the Galbraith committee. This work is likely to be one of the first domestic uses to which the original "Jason" will be put. Other applications include the calibration of radiation instruments; activation analysis and the determination of trace elements down to, and lower than, 1 part in 10^6; determination of radiation effects on materials, production of isotopes for process control and short-lived isotopes for medical and research work.

The last of these applications was demonstrated at the inauguration ceremony of "Jason" when a small specimen of manganese was irradiated in the reactor and the resulting radioactive isotope was taken by motor-car to Slough College of Further Education, where it will be used for experimental work.

The original "Jason," which was described in our issue of April 10, 1959, is a thermal heterogeneous reactor based on the design of the "Argonant" at the Argonne National Laboratories, U.S.A. It operates at a maximum power of 10kW, using enriched uranium fuel, moderated and cooled by light water, with internal and external graphite reflectors. At 10kW the maximum flux is about $1 \cdot 5 \times 10^{11}$ neutrons per square centimetre per second.

Briefly, the core consists of a cube of graphite containing a centrally located water annulus formed by two concentric aluminium tanks, one of 2ft diameter, the other of 3ft diameter.

The fuel elements consist of plates of a mixture of uranium oxide and aluminium, clad in aluminium and assembled in boxes to give about 350 grammes of ^{235}U per box. These boxes are interspaced with graphite fillers to occupy the annular space; the pattern of fuel element boxes and graphite fillers can be rearranged to give various loadings. Purified light water passes up between the fuel plates to act as moderator and coolant. This water is circulated in a closed loop and gives up its heat in an external cooler.

The internal graphite reflector (diameter 2ft) inside the inner cylinder has a central hole and four additional holes, as illustrated overleaf, which can be used for pile oscillator measurements and danger-coefficient experiments. The control rods are in the external graphite reflector and the top face is, therefore, left free of control mechanisms. This arrangement simplifies the operations of loading fuel assemblies, the placing of experiments in the internal reflector, and the positioning of external exponential experiments directly on top of the core. Moreover, the internal reflector is easily removable so that the central position can be used for internal exponential experiments—a technique that is useful in the study of reactor lattices.

Next to one of the faces of the graphite reflector is a thermal column containing fourteen horizontal ports for experiments. Against the opposite face is a mobile flat bed truck carrying a water tank in which shielding experiments can be conducted. There are two other experimental ports; they are horizontally placed in the other two opposing faces. Altogether, there are twenty-one horizontal and vertical ports.

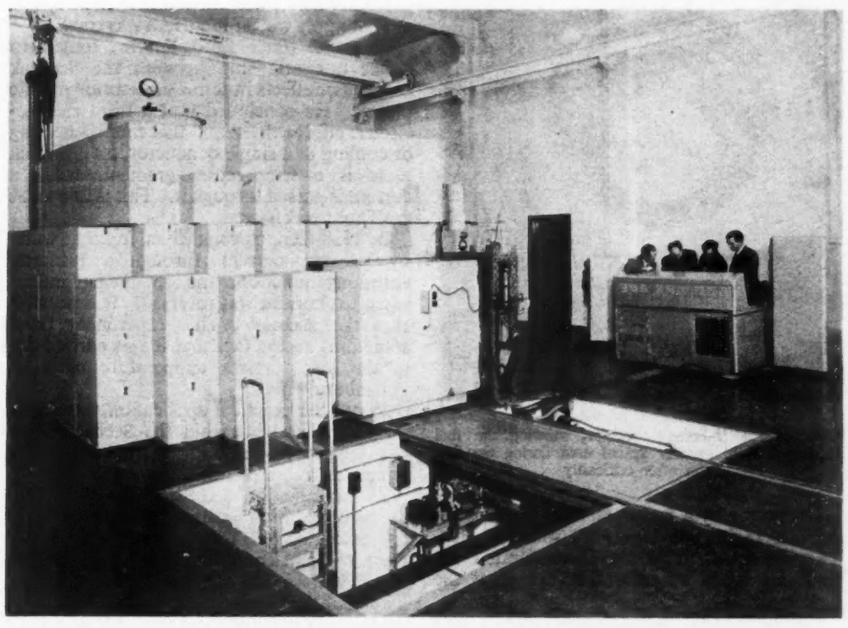
Control is effected by three safety rods, two control rods and one shim rod for fine adjustments. All the rods are of cadmium. They are normally held in the "shut down" position by gravity with spring assistance and they are actuated by electric motor drive, the system being designed to "fail safe." The reactor can be shut down by insertion of the control rods and safety rods and by "dumping" of the water from the core. Instrumentation is associated with these controls to provide automatic shut down in the event of deviation from preset operating conditions, including excessive power, "doubling" rate, temperature, neutron population, or background radioactivity.

The water in the primary circuit is purified in a small ion exchange plant which can be seen near the right-hand corner of the reactor in our first illustration. In this purification plant the water is also monitored for gamma activity. The heat exchanger consists of two coils immersed in a liquid-filled tank; one coil carries the primary circuit water and the other the mains cooling water. The pressure in these coils is greater than that in the tank so that any leakage is into the tank where the effect of such an occurrence can be observed. The mains cooling water pressure is greater than the other two so that the possibility of leakage of radioactivity into the drains is thereby prevented.

There are five main variants from the "Jason" reactor outlined above. In all cases the core components and external reflectors are identical and it follows that reactor No. 1 can be converted to provide extended experimental facilities and power.

1. A reactor of 1W to 100W, having five irradiation ports in the central thermal column and beam holes externally as required. This form of the reactor is suited for driving internal exponential experiments, oscillator experiments, production of short-lived isotopes and activation analysis. The maximum thermal flux is between $1 \cdot 5 \times 10^7$ to $1 \cdot 5 \times 10^9$ depending upon the reactor power.

2. A reactor of 1kW to 10kW having internal and external thermal columns and two beam holes giving a total of twenty-one irradiation ports. This reactor increases the



"Jason" reactor of the Hawker Siddeley Nuclear Power Company, Ltd. It is a thermal heterogeneous reactor with a maximum neutron flux of $1 \cdot 5 \times 10^{11}$ neutrons per square centimetre per second at 10kW maximum power, and is intended for research and training

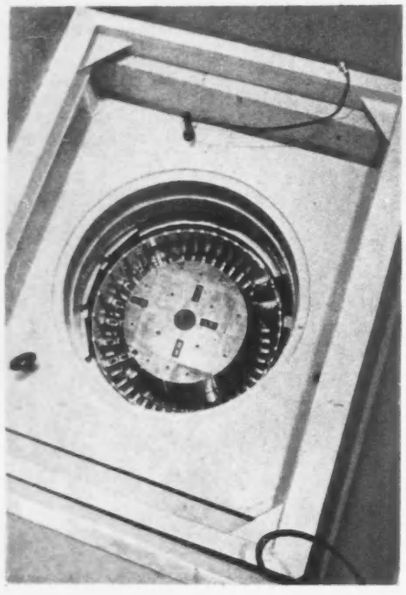
quantity and extends the range of analyses, which can be performed with the reactor 1.

3. The standard 10kW (continuous) reactor with internal and external thermal column and a shield tank, as described in this article.

4. A 10kW (continuous) "Jason" with one internal and two external thermal columns. This reactor can be used for driving two external exponential experiments or for applications where there is a requirement for a large irradiation volume for activation analysis, isotope production or oil, grease and plastic irradiations.

5. "Jason" can be provided with a 10in beam hole for neutron therapy studies giving an average thermal flux of 8×10^8n per square centimetre per second across the beam hole with the reactor operating at 10kW. Such a reactor would normally be provided with internal and one or two external thermal columns.

A zone of higher flux can be incorporated in the reactor by the installation of a central heavy water irradiation space, which will increase the available thermal flux at any given power by a factor of 1·5 to 2 and will offer a region of highly thermalised flux. These reactors may also be operated for limited periods at powers in excess of the continuous rating.



Core of the "Jason" reactor, showing the fuel loading (left of annular space) used during the first run after criticality

A reactor of the "Jason" family has been ordered by the United Kingdom Atomic Energy Authority from the Hawker Siddeley Nuclear Power Company, Ltd., as announced during the opening ceremony of the original "Jason" at Slough. The new reactor will be known as "Nestor" (Neutron Source Thermal Reactor) and will be installed, to be in operation by December, 1960), at the A.E.A. establishment at Winfrith, Dorset. "Nestor" will be used to provide the neutrons for the experimental assemblies of nuclear fuels and moderators needed to yield information about the design of future reactor systems.

For "Nestor" the "Jason" design has been modified to be capable of continuous operation at 10kW and the layout has been altered in such a way that up to five experimental assemblies can be operated simultaneously.

Thermoelectric Cooling

Apart from thermocouples for temperature measurement and thermopiles for detecting energy radiation, there have been few practical applications of the thermoelectric effects discovered by Seebeck and Peltier about 130 years ago. However, recent work in the field of semiconductors has resulted in the production of materials that may make thermoelectric cooling feasible on a commercial scale. Some of the possibilities are outlined in the following communication from the Research Laboratories of The General Electric Company, Ltd., England.

RECENT developments in thermoelectric cooling are the results of applying new semiconductor materials, evolved in studies of solid state physics, to certain principles discovered in the classical physics of the early nineteenth century.

Seebeck observed, in 1821, that a potential difference develops when the junction of two dissimilar conductors is heated. He misunderstood the meaning of his results, but his arrangement of materials in a thermoelectric series is substantially the same as that recognised to-day. A second thermoelectric effect was discovered by Peltier in 1834. He showed that heat is absorbed or generated when a current passes across the junction between two dissimilar conductors, and the direction of flow of the current determines whether the junction becomes cold or hot. This effect is distinct from the normal Joule resistive heating effect, but is superimposed upon it. Again, the results were misinterpreted and it was thought that Joule's law did not apply when the current was small.

Thomson (later Lord Kelvin) sought to define a relationship between the Seebeck and Peltier effects in terms of thermodynamic theory. He concluded that a third thermoelectric effect existed and that there is heating or cooling in a single conductor, along which there is a temperature gradient, when a current is passed through it. This is known as the Thomson effect.

In 1838 Lenz succeeded in freezing water by passing current through a bismuth/antimony junction, the ice being melted when the current was reversed. It is possible that the success of his experiment owed something to the fact that it was carried out in the low ambient temperature of a St. Petersburg winter.

Very little practical application was found for these discoveries but the Seebeck effect has long been used in thermocouples for temperature measurement and in thermopiles for radiation detection. In both these applications, high sensitivity compensates for low efficiency but, until recently, even inefficient thermoelectric refrigeration based on the Peltier effect was impossible with the materials then available.

However, a basic theory of thermoelectric refrigeration was derived by Altenkirch in 1911. He was able to express the coefficient of performance in terms of a figure of merit calculated from the thermal electromotive force coefficient and the thermal and electrical conductivities of the materials of the thermocouple. Practical refrigeration was not possible, however, until the new semiconductor thermocouples became available in very recent years.

Theoretical Considerations

It can be shown* that the maximum value of the performance ϕ is :

$$\phi_{max}=\frac{T(\sqrt{1+\theta^2}-1)}{\Delta T(\sqrt{1+\theta^2}+1)}-\frac{1}{2} \quad . \quad . \quad (1)$$

* "Thermoelectric Cooling," H. J. Goldsmid, B.Sc., Ph.D., *Proceedings of the Institute of Refrigeration*, Vol. LV, to be published.

where

ΔT is the temperature difference (T_H-T_C) between the hot and cold junctions,

T is the mean temperature, $\frac{1}{2}(T_H+T_C)$

and

θ is the figure of merit of the thermocouple, given by

$$\theta=\frac{(\alpha_p-\alpha_n)T^{\frac{1}{2}}}{(\kappa_p/\sigma_p)^{\frac{1}{2}}+(\kappa_n/\sigma_n)^{\frac{1}{2}}} \quad . \quad . \quad . \quad (2)$$

and

α is the thermal electromotive force coefficient

κ represents thermal conductivity

σ represents electrical conductivity,

and the subscripts p and n refer to the positive and negative elements of the thermocouple, which must have absolute thermal electromotive force coefficients of opposite sign.

As $\theta\rightarrow\infty$, ϕ tends to

$$\frac{(T-\frac{1}{2}\Delta T)}{\Delta T}$$

which is the coefficient of performance of an ideal thermodynamic machine. By setting $\phi_{max}=0$ the maximum temperature difference may be found from

$$\frac{\Delta T_{max}}{T}=2\frac{\sqrt{1+\theta^2}-1}{\sqrt{1+\theta^2}+1} \quad . \quad . \quad . \quad (3)$$

When the temperature difference is appreciable, considerable variations of α, σ and κ occur over the length of the couple. It is found to be desirable in making calculations to use the mean values of these three quantities over the range of temperature concerned.

Cascade arrangements of thermocouples may be used to obtain greater differences of cooling than are possible with a single stage. The first stage is then used to provide a cold sink for the hot junctions of a second stage, which may, in similar fashion, provide an even colder sink for a third stage, and so on. For practical reasons it is considered advisable to limit the arrangement to two stages.

Semiconductor Thermocouples.—Equation (1) shows that high values of θ, the figure of merit, are required in the application of thermoelectric refrigeration, and it can be shown that values of θ approaching unity are essential. In equation (2) it would be more convenient to have separate values of θ defined for each element in terms of

$$\theta_p=\alpha_p\sqrt{\frac{\sigma_p T}{\kappa_p}}$$

$$\theta_n=-\alpha_n\sqrt{\frac{\sigma_n T}{\kappa_n}}.$$

If σ/κ is the same for each element, then θ is the arithmetic mean of θ_p and θ_n, and this is effectively true for the best thermocouples. The ratio σ/κ is substantially the same for all metals at a given temperature and the best choice for thermoelectric applications are those with the highest values of thermal

electromotive force coefficient. Such combinations are found amongst the alloys of bismuth and antimony. In semiconductors the ratio σ/κ is usually much smaller than for metals but this apparent disadvantage, from the thermoelectric point of view, is often more than counterbalanced by a very much higher value of thermal electromotive force coefficient, which may well rise to millivolts per deg. Cent. instead of units of tens of microvolts per deg. Cent. for metals.

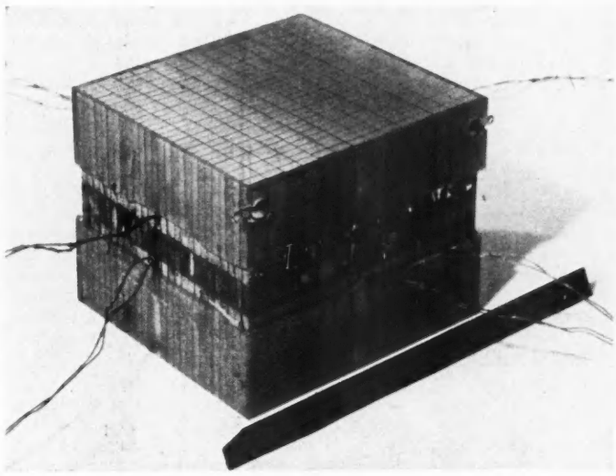
Thermoelectric coefficients in semiconductors are high when the carrier concentration is low and low when the carrier concentration, and therefore the electrical conductivity, is high. There is thus a conflict between the requirements, for a high figure of merit θ, that both the thermal electromotive force coefficient and the electrical conductivity should be high. Both these characteristics can be modified by varying the concentration of impurities in the semiconductor, and the optimum value of θ is obtained when the thermal electromotive force coefficients are about $\pm 200\mu V$ per deg. Cent. The figure of merit depends upon other factors which are capable of a degree of control, such as carrier mobility and the effective mass of the charge carriers, but prediction of the value of the functional combination of all the factors which defines the end result is complicated and difficult. In a given series of semiconductors, however, such as the Group IV elements, diamond, silicon and germanium, or the intermetallic compounds of Groups III and V, it is found that improvement in thermoelectric performance generally goes with rising atomic weight. The best compound semiconductors developed so far for thermoelectric applications are lead telluride and bismuth telluride, both formed from elements of high atomic weight. The best thermocouple combination of this kind found so far is formed from p-type and n-type bismuth telluride, Bi_2Te_3, with an overall figure of merit θ of 0·76 and giving, at a mean temperature of 290 deg. K. (17 deg. Cent.), a maximum temperature difference obtained by Peltier cooling of 65 deg. Cent.

If, however, the semiconductor compound is alloyed with an isomorphous material the thermal conductivity of the alloy may be reduced with no change in the carrier mobility, or at least only a relatively small reduction in this parameter. Such alloying may therefore improve the thermoelectric properties of the material. It has been found possible to form solid solutions between bismuth and antimony tellurides (Bi_2Te_3 and Sb_2Te_3), bismuth selenide (Bi_2Se_3) or bismuth sulphide (Bi_2S_3). Some of the best combinations of the resulting alloys made in the Research Laboratories of The General Electrical Company at Wembley have given an overall figure of merit of 0·86 and a maximum temperature difference of 80 deg. Cent. at a mean temperature of 17 deg. Cent. The improved results followed a reduction of thermal conductivity with no substantial change in the electrical conductivity or thermal electromotive force coefficient.

Although the preparation of thermoelectric semiconductor materials is simpler than that of the preparation of semiconductors for transistors, the control of composition of the compounds, and alloys of compounds, required does present difficulties. Nevertheless, polycrystalline material is acceptable rather than the single crystals necessary for producing transistors and the impurity requirements are less stringent by a factor of 10^4 or 10^5. The thermocouple elements, cut from ingots or sintered from powder pressings, are soldered together and assembled in units such as those illustrated here.

Practical Applications

Although a temperature difference of 80 deg. Cent. is possible with the best semiconductor thermocouples it is achieved only when the unit is doing no work. When operating with reasonable efficiency, differences of temperature across the thermocouple of some 30 deg. to 50 deg. Cent. are obtained. The efficiency of operation increases with smaller temperature differences and decreases as the difference of temperature is made larger.



Thermoelectric cooling assembly built up of 182 junctions

When the thermocouple is used to cool the air in an enclosure further temperature gradients are set up between the thermoelectric junction and the air. The drop in air temperature which can be achieved then becomes 20 deg. to 30 deg. Cent. If a greater degree of cooling is required a second stage thermoelectric unit must be added. This will need to have a greater capacity and loading than the first stage.

A single thermocouple designed to work with a moderate direct current, in the range 5A to 10A, has a cooling power limited to about $\frac{1}{4}$W. Cooling units of many watts capacity are made from a large number of thermocouples, usually mounted side by side and connected electrically in series. The thermoelectric cooling principle offers the facility of designing proportionally smaller units down to very low levels of cooling power.

The use of thermoelectric cooling for domestic refrigeration is an obvious possibility which offers the advantages of silent operation and avoidance of the use of chemical refrigerants, but requires a small rectifier/transformer unit to supply the direct current. The exploration of this potential application is receiving very careful study, in which technical problems and technical performance are being assessed alongside true economics. Note has to be taken of the very high degree of economy in manufacture which the conventional refrigerator industry has achieved.

There are many fields of instrumentation and engineering in which thermoelectric refrigeration appears to offer more opportunities. Instruments which have already been developed and described include an automatic dew point hygrometer, a cooled baffle for an oil-diffusion vacuum pump and a thermostat for electronic equipment. There are many interesting possibilities opened up in the prospect of being able to maintain control units, for example, oscillator crystals, at stabilised temperatures below ambient. The power handling capacity of transistors and other components may be increased if local cooling by thermoelectric means can be applied.

Other possible applications of thermoelectric cooling arise in the fields of medicine and biology. Its use in surgery is perhaps somewhat problematical because the space available for the insertion of a cooling unit in the patient during an operation is limited and the amount of heat which must be extracted, for example to cool down arteries, is much larger than would at first sight be expected—the human body is remarkably effective in its power to maintain a flow of heat to a locally chilled area. There is a possible use for cooling measuring equipment and microtomes, where constant low temperature is important, and for cold-storing specimens in the portable carrying equipment in which they are conveyed, for example, from the operating theatre to the pathology laboratory. A thermoelectric cool chest would be an excellent solution to the problem of storing biotics and antibiotics in hospitals and in doctors' surgeries.

Symposium on Graphite for the "Dragon" Project

The O.E.E.C. High Temperature Reactor Project (the "Dragon" Project) has held a four-day technical symposium at Bournemouth on the use of graphite in reactor fuel elements. It was attended by ninety scientists and engineers from Government organisations and private firms in ten European countries; participation was limited to individuals and organisations working on graphite.

The use of graphite to contain the fissile material, and to provide the necessary moderator, is a fundamental concept of the "Dragon" reactor experiment, to be constructed at the United Kingdom Atomic Energy Establishment, Winfrith, Dorset. It will replace the more conventional practice of canning the fuel in metals such as the magnesium alloys, aluminium, zirconium or stainless steels which are used in existing reactors. However, graphite that is required to contain the fissile material will have to withstand the very arduous conditions produced by the high temperatures and radiation fluxes and should also be impermeable to radioactive fission products, many of which are gases.

The object of the Bournemouth symposium was two-fold: first to discuss and review the characteristics, the development and the production of special graphites for use in high temperature reactors and, secondly, to exchange knowledge of methods of making such graphites impermeable.

It was the first such international exchange of knowledge to be arranged as part of the "Dragon" project, itself the first international atomic energy venture sponsored by the O.E.E.C.'s European Nuclear Energy Agency, to have the United Kingdom as the host country.

Woolwich Arsenal and its Machines

At a meeting of the Newcomen Society on Wednesday, December 2, Brigadier O. F. G. Hogg read a paper on the development of engineering techniques at the Royal Arsenal, Woolwich. The first part of the paper dealt with the growth of the Arsenal following the establishment of the gun wharf in the sixteenth century and described the subsequent crane installations. The latter part of the paper, extracts from which are given here, surveyed other machinery installed in the eighteenth and nineteenth centuries.

THE first machine, if it may be dignified by such a name, was the boring engine built by Andrew Schalch, the first Master Founder. We are told on June 21, 1717, that "fine copper mixed with other gun metal is issued to Mr. Schalch for the female of the great screw for the boring engine at the Royal Foundery." No further details of this museum piece are recorded, although it remained in operation until it was replaced by the new model introduced by the VerBruggens, who succeeded Andrew Schalch as Master Founders. This machine was of Dutch origin and when installed was considered to be very advanced in design. The original example was built by the VerBruggens in 1770. It was a horizontal engine in which the boring head remained stationary whilst the gun was made to revolve by the united efforts of four horses. There were actually two of these contraptions in the turning and boring room, in the south-east and south-west corners of Dial Square. In addition, there was a smaller instrument of a similar type for boring brass mortars. Dr. Andrew Wynter, writing in the *Quarterly Review*, January-April, 1858, states: "Up till as late as the year 1842 the machinery within these stately old walls (i.e. the Royal Brass Foundry) was almost as antiquated in character as themselves. The three great boring mills moved by horses which had been imported from The Hague in 1780 as astonishing wonders, were the only engines used in England in making Her Majesty's ordnance till fifteen years ago." Dr. Wynter was not quite correct in his details. The machines were not imported in 1780; they were made in Woolwich Arsenal by the VerBruggens in 1770–71. They did, however, survive till 1842.

The first application of steam power in the Woolwich factories occurred in 1805, when a steam engine and a planing machine for the Royal Carriage Department, the pioneer of machinery in the Royal Arsenal, were ordered from Mr. Joseph Bramah on June 26, 1805, in conformity with the specification drawn up by Captain George Hayter, commanding the Royal Engineers. Steam power had been used prior to this in the construction of the great wharf which commenced in 1801–02. This is evidenced by the fact that on September 15, 1806, Mr. Lloyd, of Lloyd and Ostell, was authorised to repair the steam engine used in this operation at a cost not exceeding £350.

On November 9, 1807, the C.R.E. was instructed to provide two reverberatory furnaces in the Royal Carriage Department at an estimated cost of £177 11s. 11¼d. and at the same time, Colonel Cuppage, the Inspector, was authorised to purchase a large circular saw for his department at a cost not exceeding £30. This was to be driven by Bramah's steam engine and used for ripping boards. The bill submitted by Bramah and Son for the machinery Mr. Bramah supplied in 1805 in connection with the steam engine and planing machine for the Royal Carriage Department did not satisfy the Surveyor-General, who sent it to Colonel Cuppage for his remarks. The latter reported ruefully that "a respectable house in London would have supplied the articles for £33 6s. 6d., but that Mr. Bramah had a patent for the machine." This bill for £49 was, therefore, paid by the Board, but they ordered that in future tenders should be sent out "to all tradesmen."

A far-reaching innovation took place in the Royal Arsenal during 1808. This was the proposal to erect a sawmill in the Royal Carriage Department. The scheme was eventually carried through after sundry delays and the credit for this undertaking belongs to Marc Isambard Brunel. Colonel Cuppage, Inspector, Royal Carriage Department, wrote to the Board on April 25, 1808, proposing that an engine should be introduced into his factory for the cutting of timber. In that letter he stated that Mr. Brunel, the Director of Block Machinery, Portsmouth, who worked a vertical sawmill there, was understood to be the most experienced person to consult and that he proposed to visit him. The Board approved of this suggestion on April 27, 1808; Colonel Cuppage then visited Portsmouth and reported the result of his interview with Mr. Brunel. In this report he suggested that the Royal Carriage Department should be equipped with a 12 h.p. engine and machinery for vertical and other saws. On receiving this report, the Board asked Captain Hayter to comment on its contents. The C.R.E. replied in a favourable vein and opined that considerable savings should accrue from the erection of a sawmill in the carriage factory. On the same day, the Board asked Mr. Brunel, then living in Chelsea, to submit his proposals for the steam engine. On July 1, 1808, Mr. Brunel replied that he would forward his plans in due course, but pointed out that a 12 h.p. engine would not be sufficiently powerful to deal with the load contemplated; he would recommend an 18 h.p. engine. In a letter dated August 3, 1808, Mr. Brunel forwarded to Mr. R. H. Crew, Secretary to the Board of Ordnance, his terms for converting the Royal Carriage Department to machinery, stating that, in addition to the power required for operating the sawmill, the department would require some 4 h.p. for working lathes. His calculations led to the conclusion that an 18 h.p. engine would be necessary, though he recommended one of 20 h.p. This would cost only an extra £100 and, in proportion, be more economical in fuel, since it would not be required to run at full capacity. With his letter he enclosed the following complete specification: "A 20 h.p. engine with cast iron beam and water cistern; the whole to be fixed upon an entire cast iron foundation plate. Also, two wrought iron boilers with fire apparatus, steam pipes, &c. The whole to be of the most improved construction." Then followed specific details regarding the machinery, shafting, wheels, the saw and its essentials, the frame, the table, &c.—in all, two sets. Mr. Brunel guaranteed to provide the 20 h.p. engine with all the machinery he had mentioned and erect it ready for use for £6000. Should, however, the 18 h.p. engine be preferred, his figure would be £100 less.

Unfortunately, the practice ground and butts stood in the way, both literally and figuratively, of this modernisation scheme, for the sawmill, if built on the selected site, would interfere with firing. The hands of the Board were therefore tied until a solution of this problem could be found. It was one which would obviously take time to effect as it meant the procurement of additional marshland for a new range. While the Board cogitated Mr. Brunel chafed. On September 5, 1808, he wrote to the Board somewhat querulously intimating that he had, by the Honourable Board's direction, submitted plans and an estimate for installing a sawmill in the Royal Carriage Department. As, through no fault of his own, the project had been postponed he now hoped that he might receive some remuneration for all the trouble he had incurred. The Board, admitting the justness of his plea, granted him a sum of £100 for the expense to which he had been put in preparing his specification. After much thought and negotiation, arrangements to move the offending practice ground and butt to another location were made and 20 acres of land were purchased on February 25, 1811. Proceedings with Mr. Brunel were, therefore, re-opened and on March 21, 1811, the latter announced that he was ready to begin erecting the machinery when instructed. On May 22, 1811, the C.R.E. forwarded an estimate of £4,104 3s. 1¼d. for constructing a building to house the sawmill's machinery. This was accepted and the work was put in hand. Meanwhile, on April 16, 1811, Mr. Brunel had submitted an amended estimate for supplying the complete engine and machinery. It was for £4600, a reduction of £1400. He said that, in addition, an extra boiler would be required which, with its accessories, would cost £450. This would make a grand total of £9154 3s. 1¼d. for the whole undertaking. The extra boiler was approved on May 27, 1812, and Mr. Brunel was ordered to provide it.

On August 24, 1812, Mr. Brunel reported that his total charges would now be £5080, of which he had only received £1000 on account of May 9, 1812. Arguments, counterclaims and appeals followed at regular intervals for more than two years. Finally, the Board, tired of this game of battledore and shuttlecock, made up their mind and announced their decision. They stated on August 12, 1814, that though Mr. Brunel had performed good service to his country they could not pay more than the sawmill had cost. They, therefore, proposed to give him a pension of £300 a year and settle his account for £6512 17s. 1d. The closing scene of this comedy was a minor tragedy. Mr. Brunel's premises in Battersea were destroyed by fire, involving him in heavy loss not only in buildings but in machinery. He therefore asked that his pension of £300 a year might be commuted into a lump sum of £4500. This request was granted on September 14, 1814. The giving of gratuitous pensions to contractors as well as paying their bills is a tree in the financial orchard which has long since withered and died. The old Board of Ordnance was a generous employer. On many occasions their servants received fat bonuses as well as their pay for carrying out their normal duties.

The faint light of the steam and machinery age was breaking over the Royal Arsenal. It was a dawn of promise which, in due course, blazed into the fierce heat of noon.

Further steam-driven machinery in the Royal Carriage Department now came under review. Whilst the other two factories were content to jog along with their antiquated methods, the carriage department was determined to forge ahead. This time it was Henry Maudslay who supplied a patent portable 6 h.p. steam engine with accessories in 1809 at a cost of £645. Further examples of new machinery over the next ten years were as follows : Messrs. Lloyd and Ostell ordered to supply the Royal Carriage Department with a machine for cutting elevating and other screws ; Mr. Bramah requested to provide the Engineer Department with a hydrostatic machine of his own invention at a price of £90 for lifting guns and drawing piles ; Henry Maudslay to supply a steam engine and machinery for the manufacture of Congreve rockets at a cost of £3798 4s. 1¼d.; Messieurs Holtzapffel and Deyerlein supplied a turning lathe for the smiths' shop in the Royal Laboratory for £225.

An extract from *London and its Environs or the General Ambulator*, 1820, gives a glimpse of the machines installed in the Royal Arsenal in the year indicated : " Amongst the great variety of important machines employed in the Royal Arsenal are those for sawing and planing timber. The straight saws, set in motion by the steam engine, which were the invention of Mr. Brunel of Battersea, work with extraordinary quickness and save immense labour. The apparatus is almost wholly composed of iron and brass ; and the transmission and the suspension of the movements are effected with great precision and simplicity. The machine called the Compass-saw was so named from its being applicable to all purposes of circular cutting, or of any irregular sweeps. It was invented by Lieutenant-Colonel William Millar of the Royal Carriage Department for cutting felloes, &c., which it performs at less than half the expense of the old mode. Its principal peculiarity consists in the application of a piston to the upper part of the saw, which at every stroke makes a vacuum by which means the saw is kept tight and what the workmen call buckling prevented. The planing machine is a most skilful application of the hydraulic presses of Pascal who, by solving the hydrostatic paradox, led the way for the late Mr. Bramah to apply its solution to mechanical purposes ; and which he did with the most consummate judgment and effect, this machine being one of his inventions. It consists of a horizontal wheel armed at equal distances with thirty-two gouges and with two planes, situated at the extremities of a diameter of that wheel, which is turned at pleasure by a steam engine. The piece of timber to be planed is moved in a straight line on a carriage which is made to advance uniformly by the hydraulic powers moved in like manner by the same steam engine. By these means, in every revolution of the gouge wheel, thirty-two distinct grooves comprised in the breadth of the third of an inch are traced on the timber, and immediately after, the slight asperities that separate the grooves are taken off by a stroke of the planes which follow the gouges by being placed nearer to the axis of the gouge-wheel. In this manner, in less than a minute, the sides or cheeks of the largest ship gun-carriage are planed. The vertical axle of the gouge-wheel is raised or depressed by a particular hydraulic press when it is necessary to plane pieces of timber at different thicknesses."

Henry Maudslay, who had intimate connections with Woolwich, supplied another steam engine to the Royal Carriage Department on January 19, 1824, for the price of £200. A new steam engine for the Royal Carriage Department was set up in Carriage Square in 1837. This necessitated the construction of a cast iron conduit from the canal to the tank of the engine at an estimated cost of £597 6s. 3¾d. The Eagle Company obtained the contract on December 13, 1837. The details were to lay 1500ft of cast iron conduit pipe at 4s. 5d. per square, to supply and fit two stopcocks at 12 guineas each, and to supply and fit a ball grating for £3 5s. 0d. In May, 1840, Mr. Napier requested that he might be employed in erecting his machine for compressing bullets in the event of steam power being applied to it. This request was approved in principle, no action at the time being taken, but as the Master-General wisely remarked " To steam we must come." Mr. Napier then decided to run his machine by steam, and, as a result, the Master-General called for a report from the Director, Royal Laboratory, on the feasibility and advantages, if any, of Mr. Napier's project being carried into effect showing the probable costs compared with those of the method of making compressed bullets then in vogue. The Director was not enthusiastic ; he was a conservative type of man. Sir Richard Vivian, the Master-General, on the receipt of the report showing the small savings which would accrue from the further adoption of steam wrote a masterly minute dated July 13, 1840.

In substance he said : " (*a*) In many instances at Woolwich work is carried out in a primitive manner by manual labour at great cost ; (*b*) in the Royal Carriage Department steam, as it should be, is the only motive power ; (*c*) I am sure that an extended use of steam, though initially a large capital expenditure would be incurred, would in the end save thousands of pounds and increase enormously productive efficiency ; (*d*) instead, therefore, of erecting only a machine for compressing musket balls, I am desirous of discussing a wide application of steam power with the heads of factories ; (*e*) in civil firms advantage has been taken of new methods of production. Government, therefore, should keep abreast of modern improvements."

Sir Richard Vivian was a far-seeing man and his minute was the prime mover in equipping the factories at Woolwich with power-driven machinery.

On February 1, 1841, sanction was given for steam power to be introduced in the Department of the Inspector of Artillery, the old name for the Royal Gun Factory. A total of £2758 4s. 3½d. was spent ; £1942 10s. 8¾d. on the erection of a boring, turning and drilling manufactory ; £442 14s. 2¾d. on an engine house, engine and boilers, and £392 19s. 4d. on the well and conduit to supply the steam engine with water. This was the second factory to turn over to steam and thus abolish the archaic horse boring mills. On January 4, 1842, orders were given for the buildings receiving this new apparatus for boring cannon to be completed without delay. Further sanction was given on September 5 to expend another £433 15s. 5¾d. on additional services to complete the arrangements for this new manufactory. The antiquated pieces of horse-driven machinery were not finally dismantled until 1846.

December 18, 1847, was a red-letter day in the history of the Royal Laboratory. It was the date sanctioning the conversion of that department to steam power, thus bringing it into line with the other two factories. Henceforward, mechanisation gradually took place and the days of manual handicraft were numbered. This was the realisation of Sir Richard Vivian's vision of 1840. On December 18, 1847, James Nasmyth, of Nasmyth, Gaskell and Co., of Bridgewater Foundry, near Manchester, submitted an estimate for £893 6s. to deliver, erect and install in the Royal Laboratory a 10 h.p. engine, boilers, shafting and gearing, for the introduction of steam power. This tender was accepted and on December 20, 1847, sanction was given to expend £150 on a small engine house. On the same day both services were ordered to be put in hand immediately. On January 11, 1848, James Nasmyth's estimate of £400 for machinery to convert the Royal Laboratory to steam power was accepted and the cost was ordered to be included in the Annual Estimates for 1848/49. The sum of £1698 12s. was also taken up in the same Estimates for providing and installing a new steam engine in the Royal Brass Foundry. This was erected without delay. Additional engines and machinery entailing considerable sums were also set up in the Royal Carriage Department.

The year 1848 ushered in the industrialisation of the manufacturing departments which henceforth thought in terms of machine power alone. This new technique was no doubt subsequently quickened by the advent of the Crimean War, but its inception ante-dated that campaign. The industrial revolution in England had been in full swing for many years and Government establishments could no longer resist the oncoming tide. As John Wilson remarked : " Steam is a tyrant." Machinery now began to assume importance in the eyes of the authorities, and during the years 1848–56 money was lavishly spent in equipping the Woolwich factories with the latest types for increasing production.

The Office of Ordnance which, till 1855, the year of its demise, maintained the Royal Factories, certainly justified its senescence. Under its ægis was ushered in a period of quickening tempo, larger establishments, a great increase of machinery and an expansion of productivity. Modernisation had been long in coming and hesitant rather than bold in its pace, but the pressure of events in both the engineering and political worlds, acting as a forcing house during the last phase of the Board's paternal care, injected a hormone of speed which galvanised the productive capabilities of the factories into life. Possibly the passing of the Board was hastened by news from the Crimea, since it did not escape criticism. However that may be, the Office of Ordnance did not starve the manufacturing departments during the days of its decline and ultimate eclipse. After the War Department took over the factories at Woolwich in 1855, the further machine tools introduced were those adopted in heavy industry. It would be impossible to list the lathes, steam hammers, drop hammers, drilling, boring and rifling machines, shrinkage pits and other engineering impedimenta over the course of a century. In this respect, Woolwich Arsenal was self-contained, including even its own gas factory, its power station and its high-level reservoir. Suffice it to say that in course of years, the Royal Arsenal became an up-to-date establishment in every sense of the word. In 1907, its area was 1285 acres, of which 407 acres were within the boundary wall and the remainder situated in the marshes ; 89 acres were covered with buildings. The capital value of these buildings on March 31, 1906, exceeded £750,000. The prime movers in use included 100 boilers and sixty-eight steam engines with a total capacity of 9700 h.p.

LITERATURE

Analysis of Linear Systems. By DAVID K. CHENG. Addison-Wesley Publishing Company, Inc., 10–12, Chitty Street, London, W.1. Price 8.50 dollars.

Analysis of Linear Systems is concerned with systems which are governed by linear differential equations. Such cases are extremely important to engineers because, as Dr. Cheng points out in his preface, the majority of practical systems are either linear or are approximately so, and in any case they are the only ones which can really be solved. The book is written for the engineer, and is not intended to be a mathematical text. It is mainly concerned with electrical systems, but a chapter is included which explains how to reduce mechanical systems to the equivalent electrical case. This treatment has the advantage that the general network theorems and notations which electrical engineers have developed to simplify the analysis of complex circuits will be applicable to all cases.

The material in the book has been carefully chosen, and should prove useful to engineers both electrical and mechanical. Dr. Cheng demonstrates not only that he is a master of the subject, but that he has the fortunate knack of being able to explain difficult points in a clear and simple way. The expression " it is obvious that " which is so often used by authors to cover a lengthy omission, is hardly ever used, and throughout the book he carefully explains where every step comes from, no algebraic steps being omitted. The book includes a large number of examples worked out in detail, as well as numerous exercises for the student at the end of each chapter. In this book Dr. Cheng explains first how to formulate the differential equations governing a linear system, and then how to solve them by classical methods and by the Laplace Transformation. He includes a chapter on the analysis and stability of systems with feedback, and another on the Z Transformation and sampled data systems. The book concludes with a chapter on systems with distributed constants.

The Laplace Transform is introduced as a development of the Fourier Integral, which has the advantage of showing how the Laplace Transform and Classical methods are related. Dr. Cheng does not quote lengthy tables of Laplace Transforms, but solves an amazingly wide range of examples by means of a few transforms and the skilful use of some general theorems. He points out that a well trained engineer should not be helpless when his books of tables are not available. Contour Integration is not used to evaluate the inverse Laplace Transform because Dr. Cheng does not assume a knowledge of it, and believes that the brief explanation which could be incorporated in a book of this nature would not be sufficient.

Dr. Cheng has written an excellent book and it is only possible to criticise it in detail. However, it suffers from an excessive number of footnotes. When following an explanation it is always disconcerting to have to refer to a note, even though it is on the same page, and when the number of footnotes is large it becomes very annoying. Most of these notes are concerning important points which would have been better included in the text itself.

An asterisk (*) has been used as is the normal convention to denote the conjugate of a complex quantity, and also to denote that a function has been sampled. It is unfortunate that it has also been used to draw attention to most of the footnotes. It would have been better to have used some other symbol for the latter purpose, since although confusion is unlikely to occur, a moment's pause is often necessary to decide the meaning of an asterisk.

In a book of this nature involving a large number of mathematical equations it is difficult to avoid misprints, and it is a tribute to the care which must have been taken that only a few have been detected.

One place where the clarity is not up to the usual standard is in Equation 3-27 on page 54, where the term N_s is defined to be the number of separate parts of an electrical network, but it is not made clear exactly what a separate part of a circuit is. Some further explanation would be useful. Also on page 294, as the reader is assumed to have only a limited knowledge of the complex variable an explanation of the term double pole would help. A slight inconsistency is that the first time L'Hospital's rule is introduced on page 141 it is used without any explanation, whereas on the subsequent occasion on page 187 a detailed explanation is added. This explanation would be better included on page 141. Also on page 76 by " no initial conditions " is presumably meant " zero initial conditions," but these two expressions do not have the same meaning. It should be emphasised that these criticisms are of relatively minor details in a really excellent book which will prove invaluable to any engineer who is likely to encounter linear systems.

Grosse Dampfkraftwerke, Planung Ausführung und Bau. Vol. 1. By KARL SCHRÖDER. Springer, 1959. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, W. Germany. Price DM.192.

THIS massive tome 11in by 8½ by 2in thick, contains 1073 pages and weighs 7 lb. It is Volume I and carries the sub-title " A power station Atlas." The compilation is a monument to German thoroughness. It contains, after a preliminary section (sixty pages) devoted to statistics (largely from U.S.A. sources) an analysis of the salient features of ninety-eight power stations (600 pages). These are mainly in West Germany, U.S.A., U.K., France, Italy, Denmark, Poland and Russia. The information is produced in the same form for each station, namely, a description, plan, elevation, cycle diagram, electrical diagram, and the salient data in tabulated form. The value of this collection to the rather small circle of engineers really concerned in power station design will be immense, in that it permits of statistical investigations. It could put an end to the sort of gossip which has passed for knowledge of current practice in other countries based on hurried visits to one or two of the most accessible stations or discussion with the most voluble characters in the industry.

Apart from a few misprints and misspellings of other than German names, e.g., Emil Huchet, Portsmouth, Schuylkill and many personal names in U.S.A., the data seem reasonably reliable, notwithstanding some apocryphal information included on the reconsideration of steam conditions for Thorpe Marsh, and the omission of feed pumps in the Ferrybridge " B " cycle diagram. A minor criticism is inconsistency of treatment of units consisting of more than one line, e.g., Thorpe Marsh 550MW set appears in the tabulation as 2×275MW, though in this case the correct rating is referred to in the text. In the case of Grosskraftwerk Mannheim, however, the total rating of the three-line 125MW set never appears nor does the tabulation make clear that this is a double reheat job. On the other hand, some, but not all, two-line sets in the U.S.A. are recognised as units. One regrettable feature is the suppression of makers' names—" for the sake of objectivity." It lessens the value of the information.

Paper, printing, diagrams and photographs are all of very high class. In a few diagrams the Siemens predilection for the use of colour is indulged. After the atlas comes a section (400 pages) containing extremely detailed descriptions by different authors of the following six stations: Eddystone, Fortuna, Emden, Gallatin, Citta di Roma, San Nicolas. For the design of several of these the planning section of Siemens Schuckert (of which the author is the director) has presumably been responsible. However, the information about the two U.S. plants is no less detailed.

It is rather saddening to reflect that the data so carefully collected are already on the way to going out of date, and, because they are mainly factual will not within a few years be of much interest except where they concern stations like Eddystone which are deliberately far in advance of the ruck. The second volume, however, which is to deal with reasons why things are done should be ensured a greater permanence. It is noted that nuclear stations are ignored. This is rather curious since in the United Kingdom at least the nuclear intruder by a sort of Gresham's law shows every sign of putting an end to the development of efficient orthodox stations within a few years.

Ground Water Hydrology. By DAVID K. TODD. John Wiley and Sons, New York, U.S.A., and Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 86s.

THIS book is intended to present the fundamentals of ground water hydrology to students and professional men, civil engineers, geologists, agricultural engineers, persons in charge of municipal and industrial water supplies and even those engaged in mining, forestry, public health and law. Hence it is possible to present only the fundamentals of the subject " with clarity as the criterion " leaving out specific examples such as may be found in the publications of the U.S. Geological Survey.

In the first two chapters, in a very attractive style, the author introduces his subject and clearly defines the tiresome terms of hydrology which have to be mastered. These may be rather alarming, but from page 23 onwards those unacquainted with the subject should be able to get a clear idea of the theory of the flow of water under the ground: thus the amount of flow through sands, joints, fissures, or whatever the voids in various rocks may be (e.g. gravels 25 per cent, clay 3 per cent), known as the specific yield is well described. The use of water

contours to show the distribution and movement underground is also adequately described although contours in themselves can hardly determine the quantity of water available as the author states (page 28).

The author also refers to underground water being in a storage reservoir, a simile objected to by some British geologists, but there is no reason why they should because most impounding reservoirs overflow or leak or both !

As to the overflow of underground water, the author refers to the eminent American hydrologist, Meinzer (to whom British hydrologists owe so much) who classified springs into eight classes varying from class (1) those above 100 cusecs to class (8) those under 1 pint per minute. There are sixty-five in the first class in the U.S., whereas in England, the largest spring is believed to be at the Portsmouth waterworks, 24 cusecs, in the second class of which there are several hundred in the U.S.

Chapters 3 and 4 deal with the theory of flow of underground water. Darcy's law and the coefficient of permeability (K) are very clearly explained and to fix ideas a useful numerical example is given, namely, that whereas with a slope in the contours of underground water of 10ft per mile with K=10, the water travels at the rate of 0·0025ft per day and with a slope of 100ft per mile with K=5000, the water travels at 12·7ft per day, or more roughly the velocity of underground water may be anything between 5ft a day to 5ft a year.

Interesting mention is made of the methods of tracing underground flow by the use of dyes, salts, electric conductivity, nuclear reaction and the possibility of dating underground water by tritium. Tritium is produced in rain by cosmic radiation and after it has entered the ground there is a diminution of the radioactive isotope, which should give a measure of the time water has been underground (page 61).

On page 68 there is set out (and mathematically proved) the very important fact that where underground contours are flattest the greatest yields of wells may be expected and where they are steep, the yields are less. The theory of "cones of depression" (the flow into wells when the water level is depressed by pumping) is always fascinating and is clearly presented but (page 84) it is unlike the author to say that the radius of the cone should be approximate or arbitrary, and to suggest that a cone of depression was a range of 500ft to 1000ft merely for practical application. With piezometric boreholes surrounding the pumped well, it should be possible, in some cases in practice, to avoid guessing K, and to calculate the exact "radius" of influence. In order to ascertain the total flow into a well it is very desirable to ascertain the area of influence or, as the author puts it, to ascertain the radius of influence (as shown on such a diagram as Fig. 4.7) which corresponds to the area of recharge. Not quite enough perhaps is said by the author about the step in the cycle of rain percolation into the ground, such as the 1in per annum equivalent to a yield of 40,000 (British) gallons per day per square mile of gathering ground.

Chapter 5 gives some data about boring and testing bores and says that racking (sudden pumping and stopping and thereby surging the water level) may cause sand grains to clog in the slots in the lining and reduce the yield (page 135). This, however, is not always so, for in limestones and other hard material alternating with natural clay or the clay produced by drilling and with large slots in the lining (if any) racking is very advantageous.

The remaining Chapters, 6 to 10, epitomise underground water fluctuation, quality of waters, large basins, geophysical exploration. On page 212 it is stated that it is extremely difficult to ascertain the safe yield of a virgin basin and that it is almost necessary to overpump in order to obtain any accurate value for safe yield ; the author must be congratulated in saying this so clearly and so honestly. In Chapter 11 there is information on recharge as on Manhattan Beach and in Amsterdam, and in Chapter 12 on sea-water balance there is the useful basic theory, proved in practice, that the depth of sea-water is equal to forty times the depth of the superimposed fresh water. The work concludes with notes on experiments by models, and gives something of U.S. law.

Generally, the book is well produced and with its bibliography of over 700 references, should have particular appeal to the student, scholar and scientist.

Dictionary of Aeronautical Engineering. By J. L. NAYLER, M.A., F.R.Ae.S., F.I.A.S. George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 30s.

WE are bound to observe of this dictionary that its definitions are not those currently accepted in engineering. It gives, for instance, **"A.M.C.**—Air Manufacturing Company . . " and under **" Aerobatics "** illustrates a flick roll consisting of two half rolls in opposite directions, a falling-leaf in which, improbably, only one wing dips, and a spin which is, fortunately, contradicted above **" Spinning."** **" Lift "** is defined as the "component of the resultant aerodynamic force normal to the wind direction and in the phase of symmetry of the aircraft," while thrust is measured parallel to the propeller axis. A Prandtl-Meyer expansion is shown to have two shock waves (although a cross-reference leads to a more conventional example) and " BOUNDARY-LAYER THICKNESS " similarly bears little relation to its illustration. The flight path profiles and airframe configurations shown under **" Guided Weapons "** are highly inconsistent and a drawing of a " helicopter powered with jet engine " shows one with shaft drive from a free turbine. However, we learn that " DIVE FLAPS " " are usually perforated with clots."

Books Received

Cutting Fluids. Esso Petroleum Company, Ltd., 36, Queen Anne's Gate, London, S.W.1. Price 7s. 6d.

Theoretical Elasticity. By C. E. Pearson. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 48s.

Heating and Ventilating. Second edition. By O. Faber. E. and F. Spon, Ltd., 15, Bedford Street, London, W.C.2. Price 30s.

Soil Mechanics for Railway Engineers. By U. G. K. Rao. High Commissioner for India, India House, Aldwych, London, W.C.2. Price 12s.

The Robertson Guide to World Screw Thread Standards. W. H. A. Robertson and Co., Ltd., Lynton Works, Bedford. Price 10s. 6d.

Friction and Wear. Edited by R. Davies. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 36s. 6d.

Mathématiques Générales. Seventh edition. By M. Denis-Papin. Dunod Editeur, 92, rue Bonaparte, Paris (6e), France. Price Fr.580.

Métrologie Appliquée. Third edition. By M. Denis-Papin and J. Vallot. Dunod Editeur, 92, rue Bonaparte, Paris (6e), France. Price Fr.580.

Machines a Calculer Electroniques, Arithmétiques et Analogiques. By M. Pelegrin. Dunod Editeur, 92, rue Bonaparte, Paris (6e), France. Price Fr.4.400.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

TEST CODE FOR GAS TURBINES

No. 3135 : 1959. Price 7s. 6d. Performance guarantees given by manufacturers of gas turbines may now be verified by means of this new British Standard test code. It corresponds in general form to B.S. 752, "Test code for acceptance tests for steam turbines" and, like that standard, it will eventually be associated with a "sister" specification. The standard for gas turbines will cover such matters as standard rating, temperatures, ambient conditions, governor performance, starting characteristics and pressure tests ; these are not therefore specified in the present test code, which contains only such definitions and recommendations for procedure as are necessary for testing gas turbines, gas turbo-generators, gas turbine-driven compressors or gas turbine-driven pumps. Gas turbines vary so widely in rating, type and duty that at first it seemed there could hardly be sufficient common ground to form an agreed test code. As the preparation of the standard progressed, however, it became clear that general principles are common to all types. The code is intended to serve as a general guide to good practice even when any type of gas turbine is specifically excluded or where some part of the code is not strictly applicable.

In addition to a general section containing definitions of terms, the code contains a section referring to preparation for tests, instrumentation, methods of measurement, conduct of tests and evaluation and reporting of results, and appendices referring to methods of conducting acceptance tests and a note on calorific values. At the present stage in the evolution of the gas turbine, it is not possible to produce a completed code and there are, therefore, necessarily some omissions in this present code which it is hoped it will be possible to remedy in the light of future experience. The work of preparing this test code was initiated by a Committee of the British Electrical and Allied Manufacturers' Association, whose draft formed the basis of the present document.

INVESTMENT CASTINGS IN METAL PART I : CARBON AND LOW ALLOY STEELS

No. 3146 : Part I : 1959. Price 6s. The first part of a new British Standard for investment castings in metal has now been produced to fulfil the needs of industry in this expanding field. Castings made from carbon and low alloy steels are the subject of this first part ; further parts to be published later will deal with higher alloy steels and special temperature steels. Castings of the type specified in this new publication are those whose manufacture involves the investment of an expendable pattern by refractory slurry ; castings by the shell moulding process are thus excluded from the scope of this standard.

Section One of the standard surveys general requirements and specifies the process of manufacture, the method of identification of the casting, the procedure for testing both mechanically and by destructive methods and the arrangement necessary for repairing castings. Section Two provides specific requirements for twelve different types of casting, many of which are sub-divided into two or three grades. The chemical composition and mechanical properties of each type of casting are detailed.

PERIODICALS OF REFERENCE VALUE : FORM AND PRESENTATION

No. 2509 : 1959. Price 6s. Intended for those who edit or contribute to scientific, technical and other periodicals used for reference over a long period, this new publication brings up to date the previous standard, published in 1954 under the title "Layout of Periodicals." The new title has been substituted since "Layout" was considered to have too strong a typographical implication to describe the content of this standard, but all the clauses of the 1954 edition have been retained with modifications incorporated in the light of comment and criticism over the past five years. The most significant change is in the clauses on "Articles and Other Contributions" which now advocate internationally recommended practice; the new standard itself conforms in the main to a recommendation of the International Organisation for Standardisation (ISO/R8).

ARCHITECTS', ENGINEERS' AND SURVEYORS' SCALES

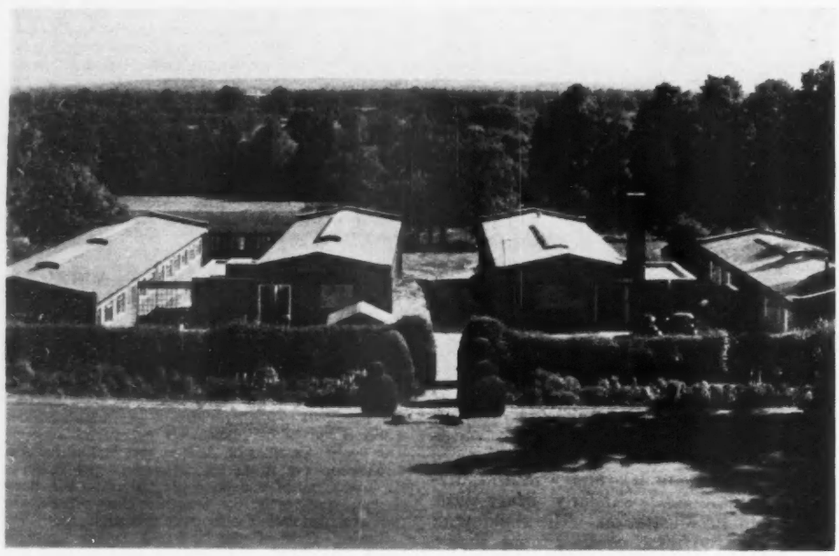
No. 1347 : Part 2 : 1959. Price 6s. This publication specifies requirements for the white opaque plastics scales used by architects, engineers and surveyors. The scales may be of either oval or flat section, and the tables given provide data on scale reference numbers, designations, subdivisions, figuring, &c.

Mainly Metallurgy

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

Sponsored Metallurgical Research

The Open Day of the Fulmer Research Institute at Stoke Poges in Buckinghamshire was held in July and, as two years ago on the former similar occasion, it was helped by ideal summer weather. The marquee on the lawn behind the main building provided a pleasant meeting place for many makers and users of metals, who had travelled there from all parts of the country. The foresight of the founders in 1946 has been proved by a still further increase in the research staff and research income, to meet a steady growth in the volume of this kind of sponsored industrial research in which the results arising from it, including patents, belong solely to the sponsor. The staff has grown from forty-four in 1947 to 112 in 1959, and the research income from £25,000 to £150,000 in the same period.



Physics laboratory, workshop building, engineering laboratory and metallurgical laboratory (from left to right) at the Fulmer Research Institute

The founder of the Institute was especially interested in aluminium alloys and in metallurgy as applied to the forwarding of novel engineering projects.

The principal divisions of the Institute still follow that practical interest in physical metallurgy; foundry, metal working and ceramics; physical chemistry, thermodynamics and extraction metallurgy; physics (including electron microscopy); engineering and mechanical testing; corrosion and electrodeposition; and chemical and spectrographic analysis. These seven divisions help to make the organisation flexible, as only such large organisations can be, where most researches are done by teams, as is now-a-days essential. Many highly specialised different departments are thus able to supply their especial know-how, trained manpower and tried-out equipment to attack the problems put forward by the sponsors.

The main building is a pleasant country mansion, and this now houses the Institute's extensive library, translation service and information and advice bureau. A number of laboratories have been built in the grounds in front of the old house, between the lawn and playing field. These house the physics laboratory, workshop building, engineering laboratory and metallurgical laboratory, as seen from left to right in the photograph. As may be gathered from the illustration, the country around the laboratories is well wooded and clean; nevertheless, the staff have easy access to London by train from Slough. Industrial scientists, whose work so often ties them to the dirt and noise of our modern black-countries, will expect much from their colleagues whose good fortune it is to work in these well-equipped laboratories in Buckinghamshire. They can enjoy the inspiration of fellowship with other scientists, such as one expects to find in universities, and yet they can concentrate on the sponsored projects unhindered by academic duties.

These almost ideal conditions of work should justify a still greater use of such sponsored research services by industry and by home and foreign government departments.

Although these researches are at first private to the sponsors, in many cases those who have paid for the work have later permitted its publication. Indeed, no less than twenty papers have been published since the previous Open Day in 1957, and upwards of a hundred papers had been published before that by the staff of this Institute. An excellent way of appreciating the width of the fields of research covered is to study the titles of these papers. Those interested in doing so may obtain a list of the papers which have been published by the staff of the Fulmer Research Institute.

The Phenomena Occurring in Steels During Quenching and Tempering

Academician G. V. Kurdjumov visited Sheffield on November 25 at the invitation of the Council of the University of Sheffield, to deliver the twelfth Hatfield Memorial Lecture, in the Firth Hall of the University of Sheffield. Since 1946 these lectures have been held either in London or in Sheffield, and they are devoted to subjects in which the late Dr. W. H. Hatfield had shown especial interest. Sheffield University administers the Fund which has made this valuable series of lectures possible, and the choice of lecturer is in the hands of representatives of the University, the Royal Society and the Iron and Steel Institute.

The previous lecturers have come from England, Scotland, Wales, the U.S.A., and France. Their subjects have ranged from historical reviews of Dr. Hatfield's service to metallurgy, developments in the iron and steel industry during the last twenty-five years, and trends in research, through wide problems of engineering significance such as gas turbines and steels for elevated temperatures, down to minute details of the metallography of steels such as nucleation and grain growth, banded structures, and ferrite. This year's lecturer spoke on "The Phenomena occurring in Steels during Quenching and Tempering"; he is the Director of the Institute of Metallography and Metal Physics, in the Central Research Institute for Ferrous Metallurgy, Moscow.

The subject was appropriate also because in many of the traditional toolmaking industries of Sheffield the quenching and tempering of steels were arts learned by craftsmen, who had no scientific instruments but made good use of their own observations and memories. The gradual spread abroad of the use of microscopes, in the study of the internal structures of metals and alloys, brought about the recognition of martensite as the main constituent of hardened steel, usually in the form of plates. Newer techniques of examining metallic microstructures with the aid of X-rays have helped to change the conception of what happened during the quenching and tempering of steels that was founded on the metallography of 1926. The lecturer said that in the U.S.S.R. many metallurgists and physicists have applied themselves to the problems of the austenite–martensite transformation, and it is concluded that martensite has in it the same quantity of carbon as was in the original austenite from which it was formed. They have extracted martensite by electrical methods and examined the extract by means of X-ray diffraction. They have also studied the effect of plastic deformation in the temperature range of 20 deg. to 200 deg. Cent., and the effects of irradiation by neutrons.

Time did not permit the presentation of the whole of the written lecture, which will be printed in due course. The Vice-Chancellor introduced the lecturer and the President of the Iron and Steel Institute proposed the vote of thanks. Academician Kurdjumov had visited England previously, about 1946, and he received very warm applause for delivering his lecture in English.

Wet Accumulators for Naval Steam Catapults

By G. A. PLUMMER, O.B.E., M.I.Mech.E., M.I.Mar.E., M.A.S.M.E*.

When launching an aircraft with a naval steam catapult a very high rate of discharge of steam occurs. Steam accumulators are therefore used to store steam. Originally dry accumulators were used. The article describes how wet accumulators were developed for this service and proved to have special advantages. It was found that reducing system pressure drop during a launch was more important than the prevention of water carry-over. Reference is made to the design of a special La Mont boiler for use with the steam catapult.

AIRCRAFT carriers built during and prior to World War II were provided with hydro-pneumatic catapults whereby compressed air acted upon pistons which in turn were connected to the aircraft by a system of wire ropes and pulleys, which imparted an accelerating force to the aircraft. These hydro-pneumatic catapults gave satisfaction for a number of years despite their weight and cumbersome complication. But following the last war it became apparent that the prospect of turbo-jet aircraft with increasing speed and weight would render the hydro-pneumatic catapult totally inadequate; consequently after consideration of various alternatives the steam catapult was developed by Brown Brothers of Edinburgh. The steam catapult (which was described in THE ENGINEER, January 28, 1955) consists essentially of two long steam cylinders each containing a piston connected through a connecting arm to an external trolley running on wheels along a track situated above the steam cylinders. The trolley in turn engages the aircraft by means of a hook attached to a towing bridle. To enable the piston arm to travel the length of the cylinders, the latter are provided with a slot, which is kept sealed by an ingenious arrangement of a steel sealing tape. Steam is admitted to the cylinders by means of launching valves, the precise time and period of opening and closing of which is controlled by a hydraulic servo system.

As the amount of steam required for catapults is considerable and the period of its application is so short, direct use of the ship's boilers is accompanied by serious disadvantages, and dry steam receivers were interposed between the ship's boilers and the launching valves. Early in 1952 consideration was given to various possible alternatives with a view to reducing the effect on the ship's boilers, with economy in weight and space requirements. A study of possible alternatives led John Thompson Water Tube Boilers, Ltd., to recommend to the Admiralty the adoption of wet accumulators in place of dry steam receivers. It was considered that the increased thermal storage would result in a lower fall of steam pressure during a launch of aircraft with a consequent higher average cylinder pressure during the launch, and greater acceleration force. After a mathematical survey of this proposal and a limited design study the Admiralty, in the autumn of 1952, accepted the design suggested by John Thompson Water Tube Boilers, Ltd., and placed at the contractor's disposal an existing dry receiver of a limited capacity of 500 cubic feet with a contract covering its modification to a wet accumulator, the design adopted being shown in Fig. 1.

The operating requirements presented two major problems :

1. A very high, almost instantaneous, steam discharge rate from the accumulator, of the order of about 2,000,000-3,000,000 lb of steam per hour for a period of about two seconds. In other words a controlled explosion, with probable serious priming.

2. The requirement to recharge or restore the lost amount of heat and to recover the steam pressure in the accumulator in less than one minute.

In order to meet the first major problem a special form of steam separator was devised. It was appreciated that any known type of centrifugal separator would impose severe penalties in the form of pressure drop, so it was decided to develop a scrubbing type of separator, a "Perspex" model shown in operation in Fig. 2 giving extremely high separating efficiency.

The second major problem was met by the adoption of recharging nozzles of the form previously employed in Loeffler boilers.

The completed wet accumulator was installed at the Naval Air Establishment, Bedford, in May, 1953, trials being started in August, 1953. A full-scale replica of the flight deck of an aircraft carrier was simultaneously constructed under a separate Admiralty contract with Brown Brothers, Ltd., who had previously designed the steam catapult. During the early trials the accumulator discharged to atmosphere through the launching valves, simulating conditions which would obtain during an aircraft launch. The preliminary trials indicated that the prototype accumulator was capable of delivering the required quantity of steam in the required time with reasonable carryover, which led to the next series of trials wherein the accumulator was connected to the steam catapult, and dead-loads representing the actual weight of various aircraft were catapulted along the replica flight deck and launched into arresting mounds of earth. During these early

* Formerly Director and Chief Engineer, John Thompson Water Tube Boilers, Ltd.

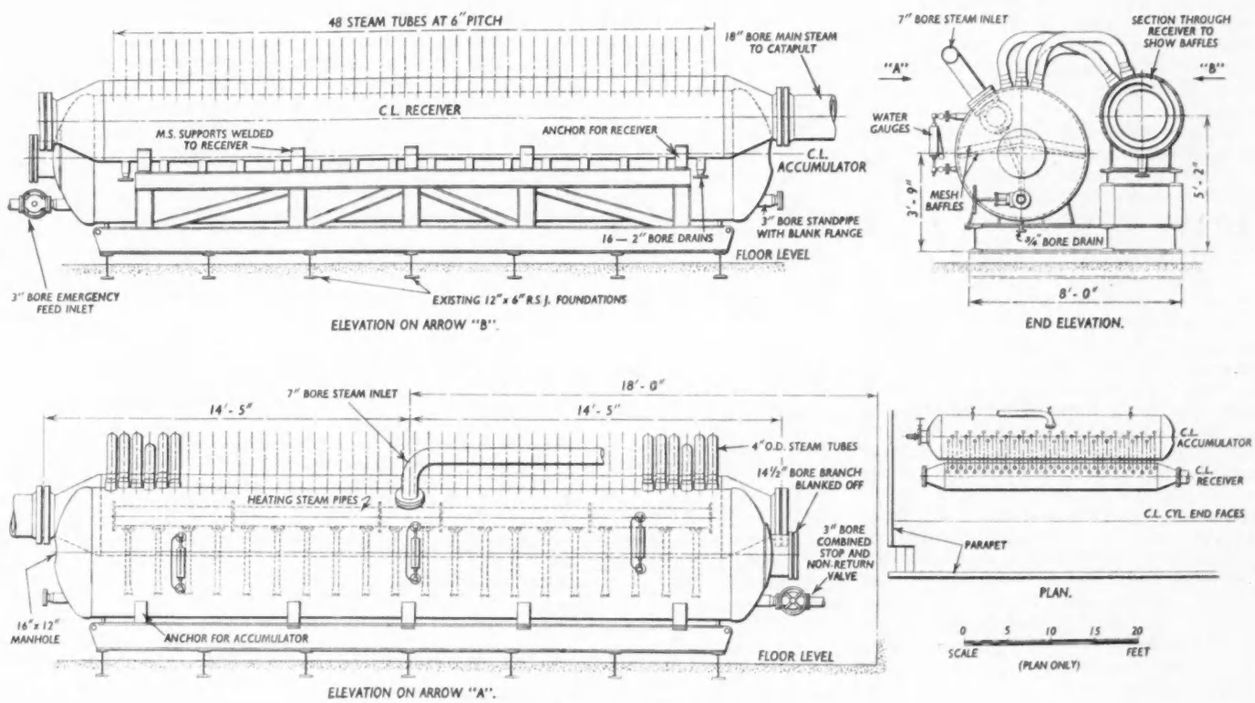


Fig. 1—General arrangement of accumulator system

trials the main emphasis was placed upon obtaining basic practical data over the full operating range of the launching valves, with a view to assessing the effectiveness of the wet accumulator and its future possibilities. From this phase onwards the staff of the Naval Air Department contributed materially, and without their active interest and co-operation it would have been extremely difficult to accumulate the enormous

Fig. 2—Scrubbing separator

amount of data that has enabled the achievement, continued improvement and extension of the original design.

In view of the extremely short periods of discharge (up to two seconds during a launch) it was at that time impossible to obtain reliable measurements during the discharge periods, despite the provision by the Naval Air Department of extremely rapid recording instruments. Accordingly measurements were taken under steady conditions :

(*a*) Prior to opening of the launching valves ; (*b*) subsequent to closing of the launching valves, and prior to commencement of recharging ; (*c*) subsequent to recharging.

By these means the total heat content of the accumulator vessel and its contained steam and water could be determined before and after a discharge, the difference then representing the heat content of the total fluid discharged, and from this could be deduced the weight of fluid discharged. The measurement of carryover proved difficult at this stage owing to the rapidity with which the conditions changed during a discharge. However, reasonably reliable measurements were eventually obtained by the use of a throttling calorimeter fitted with special resistance thermometers connected to high-speed recorders. Electrical conductivity could not be satisfactorily employed by reason of the excessive amount of CO_2 in the system introduced by the feed water. Recharging of the accumulator presented no great difficulties in measurement of steam and feed flow rates, temperatures, &c., and it was demonstrated that the required rate of recharging could be readily obtained, the temperature of the water in the accumulator being raised to within 5 deg. Fah. of the temperature of the steam in the accumulator.

These trials demonstrated that the small 500 cubic feet prototype accumulator more

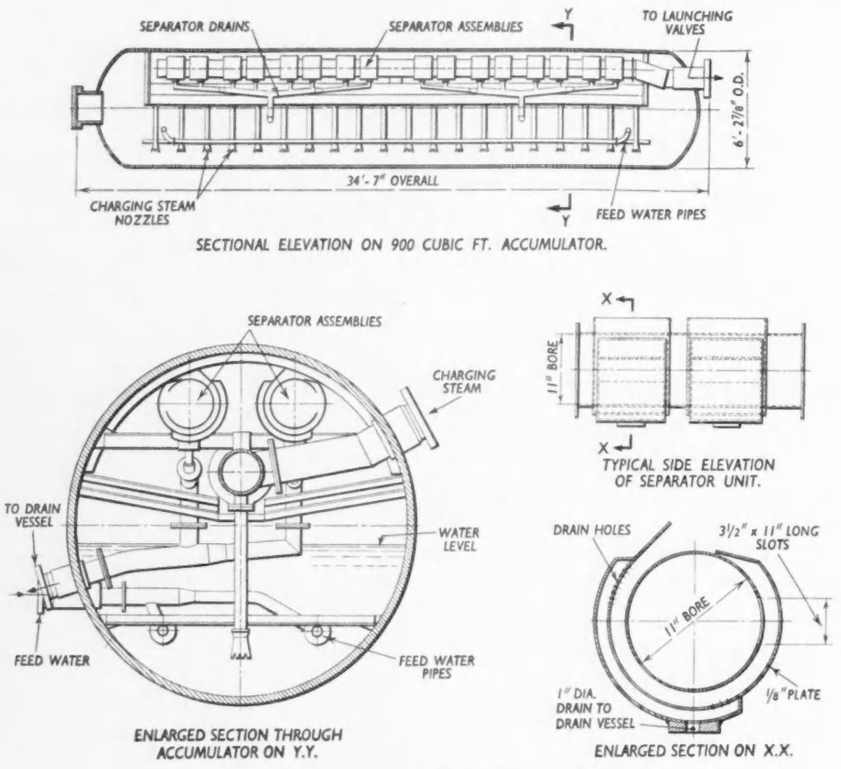


Fig. 3—900 cubic feet wet accumulator showing old internals

than fulfilled the designers' expectations and prepared the way for the next stage, which was the provision of a larger 900 cubic feet capacity wet accumulator. Whereas in the original small accumulator the design had incorporated multiple steam take-off pipes to provide equalisation of steam take-off from the accumulator to an external separator, it was decided in the new larger accumulator to make the design more compact by accommodating the steam separators internally in the accumulator. The design adopted is shown in Fig. 3. This accumulator was installed at Bedford in September, 1956, and connected to the existing steam catapult. The installation was operated successfully in this form for some six months, first using deadloads, then launching operational aircraft.

During this period instrumentation was much improved and test techniques developed considerably. A method of measuring carryover was devised whereby small quantities of sodium chloride were introduced into the accumulator. Samples of steam were collected during a launch, the chloride content of which compared with the chloride content of the accumulator water gave a direct measurement of the carryover. Steam pressure recording instruments were improved employing transducers which gave more rapid response. The fitting of pressure transducers in the steam discharge pipes immediately at the outlet of the accumulator and at the extreme end of the steam discharge pipes, established the pressure drop along the length of the steam discharge pipes during the opening of the launching valves. Having established this satisfactorily over the full period of the discharge cycle, and knowing by other measurements the total weight of steam discharged, it became apparent that the average pressure drop is equal to the average rate of steam flow during the discharge period. These instruments could thus be employed to measure the rate of steam flow, and for the first time a steam flow recorder was made available by the apparatus itself, and reference to the steam pressure charts enabled the steam flow rate to be determined at any instant during the one and a half to two seconds discharge time. It was then readily appreciated that the maximum rate of steam flow occurred towards the end

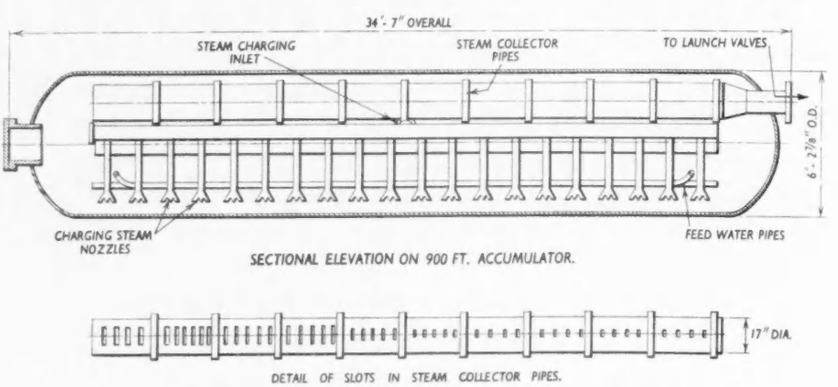


Fig. 4—900 cubic feet wet accumulator showing new internals

of the launch (when the accumulator pressure had fallen considerably) and thus it was observed that system pressure drop was of special importance.

At the same time separate investigation into the steam flow pattern inside the accumulator and within the separators indicated that the steam was not discharged equally through all the internal separators ; in fact, only about ten of the thirty-two internal separators were being usefully employed, with a consequent high pressure drop. Despite this, however, carryover was not considered to be excessive, and it was found that appreciable carryover could be accepted in the discharge system without deleterious effect on the apparatus ; in fact, a reasonable amount of carryover appears to improve the overall performance. In view of this evidence it was realised that the effect of system pressure drop had a greater retarding influence than moderate carryover. Consequently, consideration was given to the design of new internals, the accent now being on reduction of system pressure drop rather than on a high degree of steam and water separation. By this time the importance of achieving an evenly distributed evolution of steam over the whole area of the water plane in the accumulator had also been appreciated. A new design of internals was therefore developed whereby the original internal separators were removed and replaced with steam collecting pipes having slots of graduated areas throughout their entire length.

The new existing arrangement is shown in Fig. 4. Measurements subsequently taken showed a substantial reduction in system pressure resistance, reasonably evenly distributed " take-off " of steam throughout the area of the water plane in the accumulator, and a substantial increase in the catapult acceleration, without undue carryover. The trials on this plant have demonstrated the suitability of the wet accumulator for steam catapult operation, and that the wet accumulator is equivalent to dry steam receivers of two to three times the cubic capacity. The inherent characteristic of the wet accumulator itself assists the production of a " good " catapult acceleration diagram. The " self-evaporating " effect of the accumulator assists materially in uploading the steam pressure during an aircraft launch, thus maintaining a higher mean effective steam pressure on the catapult pistons. This plant is now serving extremely valuable service in proving the underframe strength requirements and launching characteristics of new and prototype aircraft with their ever-increasing weights and speeds of take-off.

The existing steam catapult is, however, capable of even greater accelerating power than is at present being used, the catapult performance being limited by the steam pressure which can be supplied by the ship's boilers, which is of the order of 400 lb per square inch in existing aircraft carriers, whereas the catapult cylinders are capable of withstanding a steam pressure of 700 lb per square inch or even higher. In view of this fact and by reason of the necessity of providing test facilities for future aircraft demanding greatly increased acceleration, the Admiralty placed a further contract with John Thompson Water Tube Boilers, Ltd., to develop and manufacture a high-pressure boiler of the La Mont forced circulation type, incorporating wet accumulators as steam drums. This installation is now nearing completion and will be the subject of a series of operational tests, following which it will be available in conjunction with a further replica flight deck for operating as a proving ground to the most advanced type of aircraft which can be visualised over the next few years. The Naval Air Department will then be equipped with land-based steam catapult test facilities adequate to deal with the proofing of all present and projected Royal Naval aircraft and in some aspects in advance of anything existing elsewhere in the world.

The design and development of this type of wet accumulator and the steam catapult boiler has been carried out for the Admiralty by John Thompson Water Tube Boilers, Ltd., under the instructions and supervision of the Naval Air Department.

Thanks are due to the Admiralty and John Thompson Water Tube Boilers, Ltd., for permission to release the information given in this article.

Vacation Training of Undergraduate Engineers

By F. ROBINSON* and R. WINDER†

Traditional methods of training students and graduates in industry have lately come in for criticism, particularly those placing emphasis on the acquirement of craft skills. This article describes an experiment in vacation training carried out jointly by the Mechanical Engineering Department of the University of Durham and Steel, Peech and Tozer, Ltd. The training was designed to interest the students intellectually as well as practically through the investigation of certain chosen technical problems which the firm desired to solve.

UNDERGRADUATE engineers are advised and, in some cases, required, to undertake employment during the long vacation in order to extend their practical experience. The University Appointments Boards are responsible for introducing students to firms, but normally they are not concerned with the detail of the work on which students are employed. This is usually decided by the firms and, consequently, the training given varies appreciably in nature and value to the students. Although many firms have excellent vacation courses, in others vacation work is not planned or supervised to the same extent as post-graduate courses. In addition, there is a growing opinion, both in universities and industry, that the traditional training methods with emphasis on craft skills are not the best for developing technical and executive staff. It has been suggested that if a mind which has been disciplined by academic study is to be developed in the industrial environment, then the same degree of intellectual participation is required in the industrial training scheme as in the university course.

Considerable attention is now being given to developing new methods of practical training and this article reports an experiment carried out jointly by the Mechanical Engineering Department of the University of Durham and Messrs. Steel, Peech and Tozer, the Rotherham branch of the United Steel Companies. In the summer vacation of 1958 a group of ten mechanical engineering students, under the general supervision of one of their own senior lecturers, worked to a planned programme of six weeks' duration. The method of training used was to employ the undergraduates on projects involving the investigation of technical problems. This method may be described as follows.

Project Method

Projects commence with a well-prepared briefing session, where details of the problem were fully described. Trainees are then left to their own devices to obtain all the relevant facts by observation and discussion with the practical men on the shop floor as well as with those people who are responsible for specific technical functions.

Among the advantages of project training are the following :—

(*a*) The trainee can tackle problems using those skills and techniques, including initiative, which have been acquired during the university course.

(*b*) Experience is gained in the methods of investigating works problems and a realisation of the difficulties involved in obtaining the true facts.

(*c*) Gaining a knowledge of human relations which comes from rubbing shoulders with many different types of people.

(*d*) Recognition of the valuable knowledge possessed by all grades of people.

(*e*) The development of that attitude of responsibility and self-confidence which comes from propounding a solution to a real problem for consideration by management.

(*f*) The satisfaction of tackling a worthwhile job.

Preliminary Planning

The course was planned in considerable detail by the authors in consultation with the staffs of the firm and of the university. At an early stage the objectives were defined as :

(*a*) To extend the students' knowledge of the technological and managerial problems involved in the manufacture of steel.

(*b*) To provide experience of the work of a professional engineer by project work similar to that which is encountered by graduates in the early stages of their careers in the steel industry.

(*c*) To investigate the techniques and possibilities of problem solving by a group of students who had no previous experience of the industry harbouring the problems.

It was specified that the projects should consist of real problems which needed solving and which should be completed within a stated time limit. A brochure was sent to the selected students giving details of the programme and information about the firm and members of its staff. To ensure full co-operation from everyone in the company, the scheme was given prior publicity through the works information sheets and the house journal. In addition, a letter stating the aims of the course was sent to all members of management by the general works manager.

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† Education Officer, Steel, Peech and Tozer, Ltd., Rotherham.

Arrangements

The students and the lecturer were accommodated at the same hotel. This arrangement facilitated discussion and the preparation of the reports. At the commencement of the course two of the company's undergraduates were attached to the group as liaison officers, but as the members of the group became more familiar with the organisation and layout of the works these two students were absorbed into the group. The course was allocated a room in the works which was equipped to enable all necessary drawings, charts and reports to be made.

The instruction given consisted of lectures, discussions, films and works visits. Some twenty lectures were given by senior members of management and technical staff. This list of lectures is given in the appendix. The lectures were followed by discussions and supplemented by visits to the plant and to other branches of the United Steel Company. This instruction absorbed approximately 20 per cent of the course timetable. The remainder was spent on project work.

Project Work

The project work was organised in the following way. The students were divided into three groups and seven projects were shared between the groups. All groups were employed on one project (No. 2) but with this exception each group worked independently on either two or three problems. Prior to the commencement of each project the group involved was briefed by members of the works staff. The other groups were also present at these sessions so that in addition to knowing the full details of each project, all students increased their own knowledge of steel works engineering practice and problems. In the projects special attention was given to accident prevention. All possible hazards were discussed at each of the briefing sessions and advice given on avoiding accidents.

On the completion of a project a report was prepared and submitted to an assessor. Subsequently a meeting was held at which all groups were present when a summary of the report was presented, the assessor commenting on the findings and the method of dealing with the problem. This assessment was followed by further explanations and general discussion by the whole course.

The Projects

Organisation of Maintenance Jobs.—Three maintenance jobs were selected ; one job was allocated to each of the three groups. Each group was required to follow through the paper work procedures from the requisition of the job to assembly on site and to record all the activities on procedure charts. Comparisons were made between planned times and actual times and criticism of the organisation and execution of the job invited. This exercise was held early in the course and afforded an opportunity for the students to become familiar with the organisation and also the project method of problem solving.

Water Balance.—For many of its processes the company draws water from the River Don. The water was pumped to a filtration plant for cleaning and treatment and then stored in a reservoir from whence it was piped to various sections of the works. The quantity of water distributed was of the order of 8×10^6 gallons per day. Information was needed on the consumption by various items of equipment and sections of the plant for costing purposes and also as a basis for the instrumentation of the distribution system. Observations of the flow were taken throughout a period of three days, on a three shift basis, and a water balance drawn up.

Scrap Handling.—Incoming scrap was unloaded, sorted, blended and pressed in the scrap stock yard. It was desired to increase the output of the press by a specified amount. The group was asked to study the operation of the stock yard and to suggest means by which the increased output could be achieved.

Design of Mill Bearings.—Encouraging results had been obtained in the works by substituting fabric bearings on roll necks in place of white metal bearings. There was, however, one exception, the bearings for the 30in mill rolls where the change over had resulted in reduced bearing life and increased roll failure. The group was required to analyse the design of the bearings, suggest reasons for the failures and make recommendations which would result in increased bearing life and reduced roll failure.

Design of Coil Handling Gear.—The existing gear for handling coils of metal strip on to mandrels was unsatisfactory due to, principally, the instability of the coils when held by the handling gear. The problem involved analysing the design and operation of the equipment and the group was asked to make recommendations for an improved method.

Method of Changing Guides on the Continuous Strip Mill.—Periodically the vertical edger guides had to be changed on the continuous strip mill to accommodate the various sections being rolled. It was considered that the change-over time could be reduced by modifications to the vertical edger. The project required the existing method of changing the guides to be investigated and a new design suggested to enable the change over period to be reduced.

Manufacture of Railway Springs.—The production of certain types of spring required the formation of an eye at each end of the main leaf for suspending the spring when fitted to a vehicle. This operation was carried out on a forging machine which had been in operation for many years and was soon to be replaced by a new one. An investigation to assess the efficiency of the operation of the machine, together with the method of handling the materials, was needed. This information would enable a decision to be made on the type of machine required to replace the existing one, and also a modified layout for the working area.

Comments on the Course

The first few days were spent quietly by the students familiarising themselves with the works and its products and also cautiously accepting the novel situation where everyone, from the chief engineer to the man on the shop floor, could be approached and interviewed to obtain information. Once this situation had been fully appreciated, the pace of the course quickened. The students, conspicuous by their badges, were soon seen around the works tactfully questioning and discussing the problems with engineers and production personnel, watching the plant in operation and studying drawings and other relevant literature. The students soon realised the difficulties to which a steel works maintenance engineer is subjected with working to a time limit to complete particular projects. They readily accepted the challenge and the project reports were without exception produced within the time limit, although this necessitated hours of effort spent in the evenings.

The last week of the course was spent on assessing the reports. Each assessor received his report early enough to make a thorough appraisal of the contents and to make constructive criticisms of the recommendations. In every project the assessors, although not always agreeing entirely with the recommendations, were impressed by the way in which the reports had been produced.

What has been the value of the course ? The undergraduates left Steel, Peech and Tozer with the knowledge that a maintenance engineer's job is a most interesting and varied one, calling for all the skills found in a variety of other types of engineering, added to which is that continued challenge of keeping the plant in operation which often demands an unusual degree of ingenuity. They also felt that the practical experience gained has placed into a different and more realistic context their own theoretical knowledge. The company was grateful for the recommendations made by these undergraduates who had looked at existing problems in a different way. Certain recommendations which were practicable would be adopted in the near future.

The opinion of both the University and the company's staff was that the course had achieved its objectives and was completely successful. The result being that another course is being arranged to take place in 1959.

The authors gratefully acknowledge the help and encouragement received from Professor Aubrey F. Burstall, and the management and staff of Steel, Peech and Tozer, a branch of The United Steel Companies, Ltd.

APPENDIX

List of Lectures

(1) Introduction and welcome by Mr. G. E. D. Halahan, General Works Manager.
(2) Steel, Peech and Tozer and The United Steel Companies.
(3) Accident Prevention in a Steel Works.
(4) Steelmaking by the Open Hearth Process.
(5) Planned Maintenance.
(6) The Structure and Responsibility of an Engineering Department in a Steel Works.
(7) Planning and Progress.
(8) Physics in Industry.
(9) Industrial Water Plant.
(10) The Traffic Department.
(11) Works Study.
(12) The Management Structure.
(13) Statistical Control.
(14) Economics of the Iron and Steel Industry.
(15) The Development Engineer.
(16) The Inspection Department.
(17) Furnace Design.
(18) Costing.
(19) Operational Research.
(20) Labour Relations.
(21) Education and Training.
(22) " Industrial Management."

Industrial Films.—A new colour film entitled " Lead the Enduring Metal " has been produced by the Lead Development Association. Intended to interest non-technical audiences, the film has been designed to offer general information on lead. After briefly tracing the metal's history and ancient usage, the main sequences demonstrate the role played by lead in the modern world and deal with its applications. Particular reference is made to the metal's power to protect against radiation hazards. Copies of the film, which runs for twenty-eight minutes, are available on free loan in 16mm size. The Carborundum Company, Ltd., has produced three new films and these were shown to an invited audience in London on October 27. " Sparkling Performance " demonstrated some of the uses of diamond abrasives with particular reference to the engineering, stone and glass trades. The second film " In the Hot Zone " deals with the subject of industrial heat control by the use of super-refractory materials, and should prove to be of particular interest to furnace or foundry workers. The third film " In the Rough " studies the role played by modern abrasives in the development of foundry and other heavy engineering techniques. All three films are available on free loan in 16mm size.

Main Line A.C. Locomotive

At a ceremony at Sandbach, Cheshire, on November 27, the first of 100 a.c. electric locomotives ordered complete or in part from various contractors by British Railways in 1957, was handed over for service in the London Midland Region by Lord Chandos, chairman of Associated Electrical Industries, Ltd. The locomotive is one of twenty-five being supplied assembled by the Traction Division of A.E.I., of which twenty-three (including the present machine) are geared for a top speed of 100 m.p.h., while the other two will have a top speed of 80 m.p.h.

THE general requirements of the British Transport Commission for a.c. main-line locomotives to work on routes electrified at 25/6·25kV, 50 c/s, single-phase called for four-axle designs weighing around 80 tons and developing between 3000 h.p. and 4000 h.p., with gearing for maximum speeds of 100 m.p.h. or 80 m.p.h. according to the duties for which they were intended. Various contractors are engaged on building locomotives or supplying power equipments for units to be constructed in British Railways workshops, and the locomotive handed over for service last week is one of twenty-five ordered from The British Thomson-Houston Company, Ltd. (whose traction interests are now merged in the A.E.I. Traction Division) as main contractor. Mechanical parts have been sub-contracted to The Birmingham Railway Carriage and Wagon Company, Ltd.

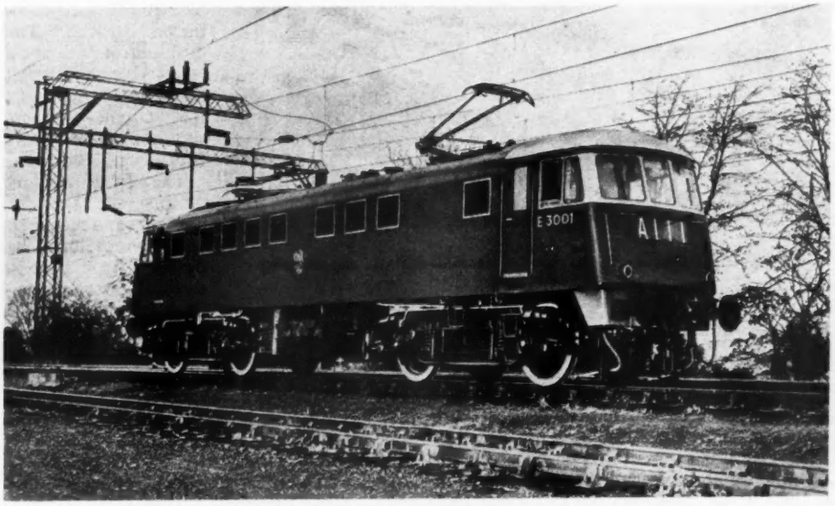


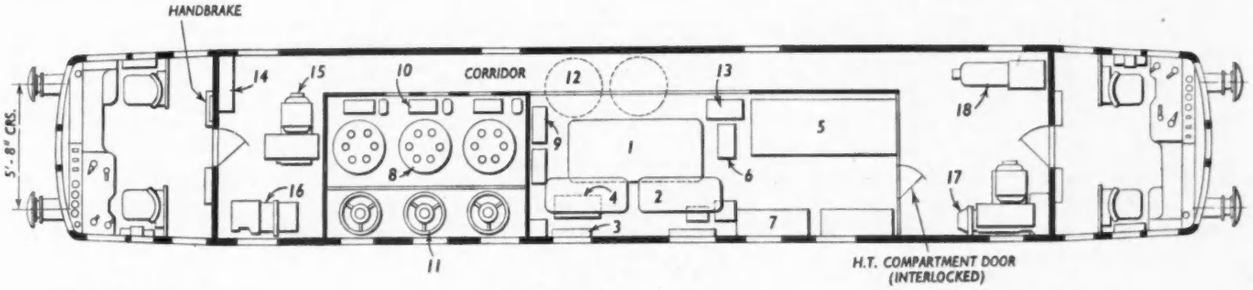
Fig. 1—High-voltage 50 c/s locomotive delivered to the London Midland Region, British Railways, where it will operate on the Manchester-Crewe section

From the general view of the locomotive (Fig. 1), it will be seen that it is equipped with Stone-Faiveley AMBR pattern pantographs, the construction and operating principles of which were described in our April 24 issue. A Brown Boveri air blast circuit-breaker is in the centre of the roof, and some details of this will be found in the same article. These are standard items required by the specification, but with regard to the mechanical transmission the contractors were free to put forward any proved flexible drive, and in the present instance have developed a form of the Alsthom coupling used first in the prototype high-speed C_0–C_0 1500V d.c. locomotives built for the French National Railways in 1949. This is the first application of the Alsthom drive principle on British Railways.

The complete body of the locomotive is designed as a weight-carrying structure and consists of a fabricated underframe with side members and centre sills of rolled steel channel section. Between the bolsters, the sideframes are of braced frame construction with deep section cantrails, joined at intervals by transverse members which also carry the pantograph feet. The transverse members, which also support the roof traps, are removable, so that the body of the locomotive can be completely opened at the top between the cab bulkheads if required for removal of equipment. Attachment of the sideframes to the underframe is by welding. In order to achieve light weight, the maximum use has been made of glass-fibre construction for such items as cab roofs, doors, bulkheads, air ducts, and even the transformer oil conservator tank.

The layout of the equipment inside the body is shown in Fig. 2. Behind each driving compartment is a space in which are housed auxiliary machines, certain control panels, and, at one end, the traction motor cut-out switch. This enables motors to be isolated individually or in any combination of two. It may be noted that the smoothing chokes are on the underframe, where they are cooled by the air flow while the locomotive is travelling and so require no special auxiliary ventilation or cooling service. Access to the central compartment containing the transformer, rectifiers and other high-tension equipment is obtained through a door which is interlocked with the pantographs and with the h.t. earthing switch. The main control unit is a rectangular assembly containing a motor-driven camshaft tap-changer and having the tap-changing contactors on one side and auxiliary contactors and relays on the other. Lamps on the fault indicator panel immediately behind one cab and accessible from the other by the side corridor, give individual warnings of motor faults, transformer and rectifier auxiliary services faults, transformer alarm, and rectifiers hot or cold. Attention is drawn to a fault in the first place by a single warning lamp on each driving desk, and it is then identified by inspection of the panel.

The bogie suspension and pivoting system embodies Alsthom principles first seen in this country in the "Explorer" diesel-electric locomotive for overseas developed jointly by The British Thomson-Houston Company, Ltd., and Lister Blackstone Rail Traction, Ltd. (see our February 20 issue). There are no axlebox hornguides, the double-row spherical roller bearing axleboxes being connected to the bogie frames by rubber-bushed radius arms giving a cushioned resistance to lateral impacts. The primary coil springs are mounted on equalising beams underslung from the axleboxes in rubber chevron mountings, and hydraulic dampers are fitted. A bogie frame fabricated from "Cor-ten" steel is carried on the primary coil springs and is provided with a single fixed bolster. The bogie secondary



1—Main transformer.
2—Transformer oil radiator (2).
3—Transformer radiator fan (2).
4—Transformer circulating-oil pump.
5—Main control unit.
6—Tap changer reactor.
7—Line breaker (2).
8—Main rectifier (3).
9—Rectifier tank balancing reactor (2).
10—Rectifier excitation unit (3).
11—Rectifier cooling fan (3).
12—D.C. smoothing choke (2).
13—Auxiliary transformer.
14—Fault indicator panel.
15—Traction motor blower (2).
16—Main compressor.
17—Compressor for raising pantograph.
18—Exhauster (2).

Fig. 2—Arrangement of main power equipment in locomotive

suspension employs a vertical column between the underframe and bogie with large rubber conical bearings at each end. Tractive effort is transmitted through the rubber, but fore and aft angular movement of the column is controlled by manganese bearing pads while side movement is controlled by pre-loaded double-acting springs. A small proportion of the body weight is taken on four four-coil support springs via manganese steel pads. Under small transverse accelerations the body oscillates about the lower pivot only, but under the influence of higher forces, sufficient to overcome the pre-loaded side control springs, the body can move sideways in relation to the bogie.

The traction motors with their gears and quill shafts are carried on three-point pre-loaded mountings in the bogie frame and are coupled to the road wheels by the Alsthom form of link drive. In this transmission two driving members at each end of the quill shaft project through apertures in the face of the wheel and are coupled by short links to opposite corners of a lozenge-shape floating member which in turn is coupled to the wheel itself by similar links. All link joints incorporate " Silentbloc " bushes.

Principal dimensions and other details of the locomotive are as follows :

Wheel arrangement	B_0-B_0
Wheel diameter	4ft
Horsepower at one-hour rating	3680 h.p.
Top speed	100 m.p.h.
Weight	80 tons
Length over buffers	56ft 6in
Bogie wheelbase	10ft 9in
Height to roof	12ft 4½in
Width over body	8ft 8½in
Gear ratio	29/76
Maximum tractive effort at peak notching current	48,000 lb
Tractive effort at continuous rating	20,000 lb
Speed at continuous rating	60 m.p.h.

The two locomotives geared for 80 m.p.h. top speed (gear ratio 26/83) will be similar except for a maximum tractive effort at peak notching current of 60,000 lb and a continuous tractive effort of 24,000 lb at 49 m.p.h.

Electrical Features

The four traction motors are supplied with direct current from three six-anode pumpless air-cooled steel tank mercury-arc rectifiers diametrically connected in parallel so that each tank has three anodes in each half-cycle. Load-sharing reactors are provided to ensure current-sharing between tanks and individual anodes. Basically the scheme provides a bi-phase arrangement feeding four motors in permanent parallel as indicated schematically in Fig. 3. The rectifiers have been developed from an industrial design, modifications including additional baffles, and narrower but deeper cathodes designed so that on track with maximum cant the mercury pool covers the whole of the cathode surface.

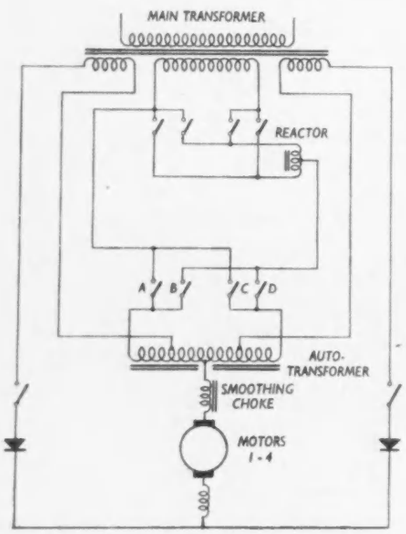


Fig. 3—Schematic diagram of main power circuit

The main transformer has a four-section primary, the sections being connected in series on 25kV and in parallel on 6·25kV by the automatic operation of an oil-immersed off-load change-over switch controlled by a voltage selector relay. Traction motor voltage is controlled by tap-changing on the secondary by means of cam-operated, air-break switches (Fig. 4). The twenty tapping contactors are used twice during acceleration by arranging for the voltage from the tapped portion of the secondary first to buck and then to boost that from the untapped sections, buck-and-boost contactors *A*, *D* or *B*, *C* (Fig. 3) being closed in pairs. By this means thirty-seven accelerating notches are provided, beginning at 70V, and these are followed by two weak-field notches obtained by field diversion. The whole of the tap-changing reactor is in circuit on all running notches, half of which correspond to the tapping voltage and half to the mean between taps, but in every case the currents circulate in opposite directions to the reactor centre tap so that voltage drop is negligible. Two high-speed circuit-breakers protect the rectifiers, making anode fuses unnecessary, and also serve as the motor contactors during normal operation. The rectifiers are pre-heated on short-circuit under automatic control, and space heaters are also fitted for raising temperature in very cold conditions when voltage could not be applied, in order to meet the requirement of operating in temperatures as low as −12 deg. Cent.

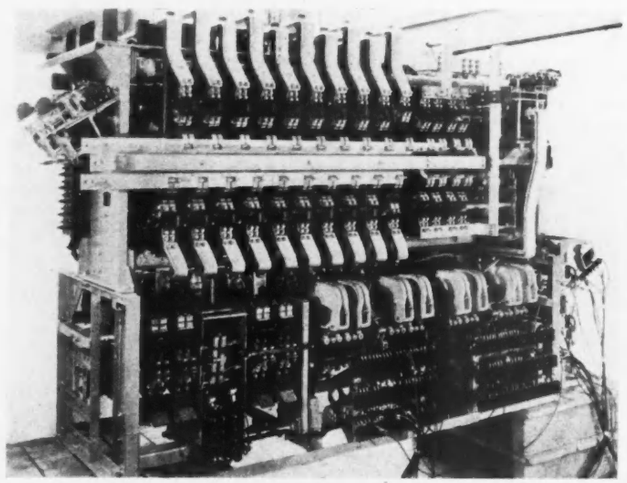


Fig. 4—Main control unit showing the camshaft-operated tap-changing contactors

Notching up or down can be effected by moving the controller to its " run " position in either direction, and arresting progression by returning it to " hold " as necessary. Alternatively the driver can notch step by step by moving the lever to and from " hold." Instruments comprise brake gauges, speedometer, two two-needle ammeters showing the current in all four motors, and a notching indicator showing the percentage of the maximum voltage applied to the motors at any time. The ammeter scales are marked with green sectors corresponding to the continuous rating, yellow sectors for twice continuous rating, and red sectors indicating a current range which must only be used in emergency. During acceleration, the locomotive has maintained a tractive effort of 50,000 lb up to 40 m.p.h. (28 per cent adhesion) and it balances on the level with a 475-ton train at 90 m.p.h. It has not been found necessary to connect the sanding equipment, but in the second and third locomotives of the series it is proposed to fit experimentally an anti-slip brake which will apply a momentary pressure of 15 lb per square inch to the brake cylinders on operation of a push-button. The brake will not be automatic, in accordance with the general policy of relying on the skill and judgment of the driver in controlling the locomotive.

Indicator lights on the control desk show that line voltage is present, that the electric heating circuiting to the train is functioning, and give a general fault warning (localised by reference to the fault indicator panel mentioned earlier). The push-button which raises the pantograph serves also to reset the circuit-breakers should these have tripped on overload.

The four traction motors are six-pole, series-wound machines specially developed for operation on a rectified 50 c/s single-phase supply. Class H insulation and special lubrication arrangements are among the design features incorporated to allow maximum periods of running between overhauls. The ratings are : continuous, 975V, 700A, 847 h.p.; one-hour, 975V, 760A, 920 h.p. The fields are shunted permanently by a small resistance to reduce the effects of ripple on commutation and two further steps of diversion are used for field-weakening. The divert resistances are carried on the underframe. Armature aud quill shaft bearings are designed to prevent overfilling with grease.

Auxiliary services are supplied from a separate transformer. Two traction motor blowers, three rectifier cooling fans, two transformer oil-cooling radiator fans and a transformer oil-circulating pump are driven by single-phase capacitor-start-and-run motors. The main compressor and one exhauster are driven by d.c. motors fed by germanium rectifiers. A second exhauster is battery-operated in order to maintain service while the locomotive is passing through " dead " sections of contact wire. A battery-driven auxiliary compressor is also installed for raising the pantograph and operating the air blast circuit-breaker when coming into service. The battery floats continuously across a " Magnestat " charger with germanium rectifier.

Principal Sub-Contractors

Electrical Parts : Transformer oil coolers, Serck Radiators, Ltd.; Transformer fans, rectifier fans, traction motor blowers, Aerex, Ltd.; Battery, Nife Batteries, Ltd.; Capacitors, British Insulated Callender's Cables, Ltd., Telegraph Condenser Company, Ltd.; Train heating jumpers, The General Electric Company, Ltd.; Auxiliary compressor, Clayton Dewandre Company, Ltd.; Cable, Siemens Edison-Swan, Ltd.

Mechanical Parts : Main sub-contractor, Birmingham Railway Carriage and Wagon Company, Ltd.; Brakes, including compressor and exhausters, Westinghouse Brake and Signal Company, Ltd.; Wheels and axles, Owen and Dyson, Ltd.; Quill drive links, Silentbloc, Ltd.; Axleboxes, The Skefko Ball Bearing Company, Ltd.; Bogie centre pivot rubbers, Empire Rubber Company, Ltd.; Windows, Beckett, Laycock and Watkinson, Ltd.; Springs, Wilfords and Co., Ltd.

Battery Vehicle Practice and Applications

The conversion of a petrol tractor to battery propulsion is described. This vehicle is for a specialised duty and operates with the two battery sections permanently in series. Details are also given of a parallel/series battery system which is used for the control of vehicles covering a wide range of applications.

THE increasing use of tractor-trailer transport for refuse collection by municipal authorities is reopening a field for battery electric traction which a few years ago appeared to be diminishing. In the immediate post-war period consideration was given to refuse vehicle chassis of 5 or 6 tons rating, a number of which were built, but there were difficulties in evolving a standard body suitable for all users. Without such standardisation the electric vehicle industry was faced with the uneconomic prospect of providing small numbers of special vehicles for different authorities. Since then the practice has extended of using standard tractors to haul trailers with specialised bodies. When this is done a battery tractor can be used to the best advantage, being employed on the frequent short start-to-stop runs involved in door-to-door collection which suit its characteristics. Diesel or petrol haulage can be adopted for the longer runs to the refuse disposal points.

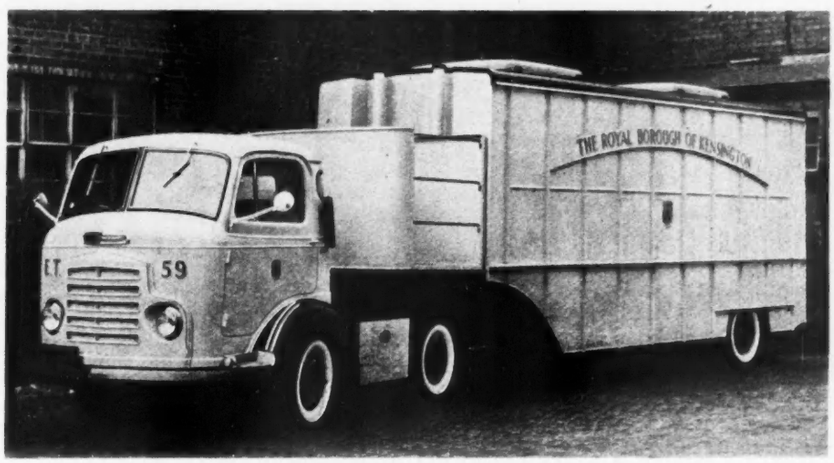


Fig. 1—Electric Karrier "Bantam" tractor and semi-trailer

With these possibilities in mind, and at the instigation of the Royal Borough of Kensington, Rootes Motors, in collaboration with Smith's Delivery Vehicles, Ltd., have developed a battery electric tractor based on the Karrier "Bantam" tractor chassis. Fig. 1 shows the tractor coupled to a semi-trailer vehicle. Battery tractors had been employed in Kensington for refuse collection, particularly at night, as early as 1936, but the present Karrier "Bantam" conversion is believed to be the first adaptation of a petrol tractor to battery propulsion. Eighteen of these units are being supplied.

Chassis to be electrified are sent to the factories of Smith's Delivery Vehicles, Ltd., Princesway, Team Valley, Gateshead, 11, and here we were able recently to see the work in progress and to inspect the electrical equipment during installation. The traction motor, made by the Electro Dynamic Construction Company, Ltd., is foot-mounted on a built-up framework and is further secured by a top support through which a bolt passes into the hole provided for the lifting ringbolt. This machine has a one-hour rating of 11 h.p. at 185A and a short-term (five-minute) rating of 16 h.p. at 480A. Transmission is through a Layrub universal joint at the front end of the propeller shaft and a Hardy-Spicer joint with needle roller bearings at the rear axle end. The existing rear axle drive, with its ratio of 7 to 1, is retained.

A further built-up framework is required at the front of the chassis to carry the drum type reverser and the two wire-wound main resistances. At the front right of the cab is the foot-operated controller, in which the contactors are mechanically operated in sequence by cams each time the pedal is depressed. The controller is made by Sharp Control Gear, Ltd. With the form of mechanism used, external protection against notching up too rapidly is unnecessary, since the fastest practicable operation of the pedal cannot result in excessive starting current.

The thirty-cell battery weighs 15 cwt and is installed in two sections, one on each side of the chassis, carried in bolt-on external angle-frame carriers. A removable angle at the front of each battery carrier secures the sections in place and is removed when it is desired to slide them out on to a trolley or other handling means for servicing. The battery ratings are 60V nominal, 55V on load and 240Ah capacity at the five-hour rate.

Apart from the electrical modifications mentioned, a hand-brake mounting has to be provided, and the motor reverser and resistances are covered by a "Fibreglass" cowl made on a plant recently installed at the works. This plant is also used for producing various body shapes and parts required for vehicles made at the works which would involve lengthy operations by other methods. "Fibreglass" material is cut with shears to the required pattern and placed in a reinforced plastic or aluminium mould (Fig. 2), which has previously been coated with a separator. The material is then brushed with a resin, in which colouring may be incorporated if desired, and sets in a few hours with a durable finish which will stand up to relatively heavy blows without denting or scratching. Present applications at the works are for roof front mouldings, doors (made in two sections with wood blocks incorporated for attachment of locks, hinges, &c.), and items such as bakery trays for travelling shops.

Fig. 3 shows the power circuit of the tractor and the notching chart. In this application both sections of the battery are permanently in series. Three resistance steps are provided, consisting of all resistance in, half resistance in, and two resistance sections in parallel. As long as any resistance is in circuit the warning lamp in the 30V control circuit, supplied from a centre tap on the battery, is illuminated. A micro-switch contact in the controller opens the lamp circuit on the fourth notch, the motor then being connected directly across the battery.

Contactor 1 is closed when the controller is "off" but is released mechanically in the other controller positions. In these positions, however, it is normally held closed electrically by its hold-in coil but it will be noted that the coil circuit is broken when the charge socket is in use. No current will reach the motor, therefore, if the controller is operated while the tractor is connected to the mains via the charging socket in spite of the mechanical closing of line contactor 2. For charging to take place, the reverser must be "off" and in this condition a further interlock in series with contactor 1 hold-in coil is open.

Other vehicles seen under construction during our visit to the factory were being equipped with B.T.H. control equipment providing parallel/series battery operation, the battery sections being in parallel to reduce the current demand during acceleration and for low-speed running, and then transferred to series if higher speed is required. Transition is effected by a push-button on the steering column. This is the system of control used in the majority of delivery vehicles built at the works, which in general are powered by smaller, higher-speed motors

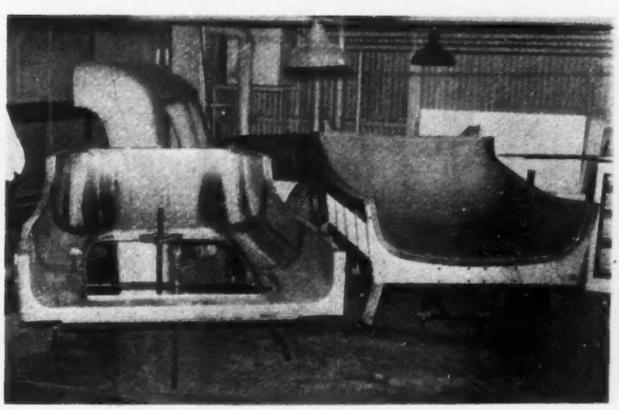


Fig. 2—Moulds for production of body components in "Fibreglass"

than the Karrier tractor described above. Typical ratings of these machines are 11 h.p., 155A, for one hour and 18 h.p., 300A for ten minutes. Currents as high as 600A may be taken without damage for brief periods on steep gradients, an example being 650A for one minute up a gradient of 1 in 4, when the motor develops 21·5 h.p. The standard transmission employs a propeller shaft with Layrub universal joints at both ends and a double-reduction final drive, the differential assembly itself being driven through a helical pinion and gear wheel.

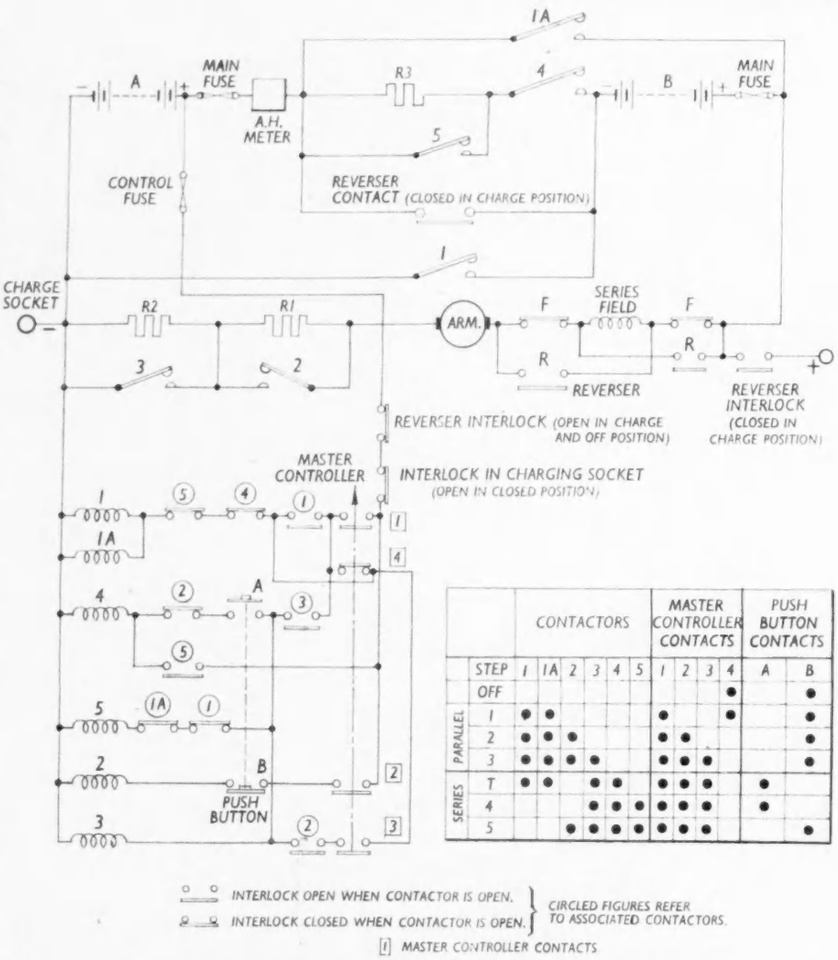
A diagram of the control circuit is shown in Fig. 4. The contactors are electromagnetic and are operated in the correct sequence by continuous depression of the controller foot pedal. When the pedal is fully depressed the push-button may be operated as described above to connect the two battery sections *A* and *B*, in series. This action restores a section of the starting resistance and initiates transition, which is completed by interlocks on the transition contactor and finally by release of the push-button, the pedal remaining depressed throughout. It will be seen from the notching chart that in the transition step *T*, while the battery sections continue to supply the motor in parallel, they are connected in series through transition resistor *R*3. This resistor is then short-circuited by contactor 5 simultaneously with the breaking of the parallel connections through contactors 1 and 1*A*, the motor now being supplied from the battery sections in series through starting resistance section *R*1. Release of the push-button short circuits the latter resistance and so the full-speed condition is attained without interruption of tractive effort.

On releasing the controller pedal, the starting and transition resistances are restored by de-energising their contactor coils so that the motor current is reduced before the opening of the contactor or contactors which finally disconnect the motor from the battery (i.e. contactor 4 when decelerating from series battery working or contactors 1 and 1*A* if the transition push-button has not been operated).

In these B.T.H. equipments the reverser is a blade switch, the handle of which moves in a gate so that selection of reverse and "charge" are well-defined movements. Interlocks in the reverser and in the charge socket on the vehicle interrupt the feed to the master controller in series when "charge" has been selected.

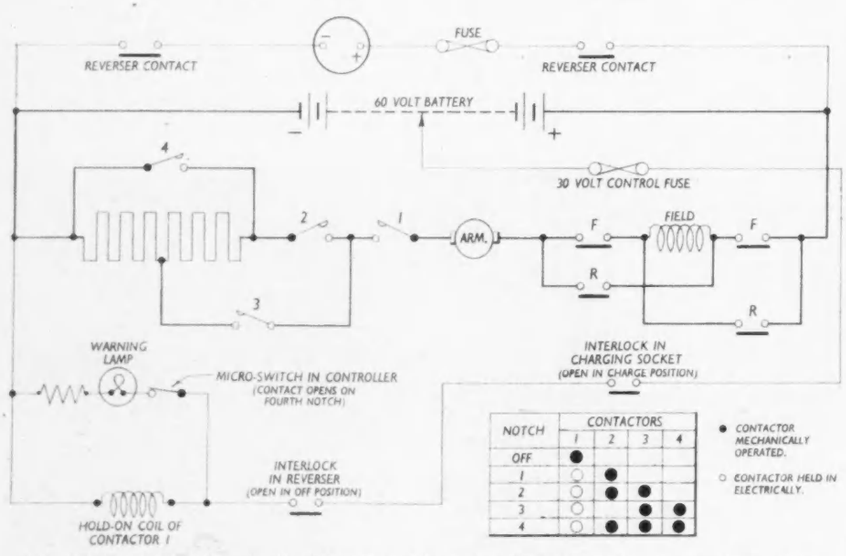
The operating time of the contactors is such that if the driver depresses the pedal too fast the first step is not made and so the others do not follow. Master controller contact 4, normally closed, does not open until after controller contact 1 has closed, and it is through these two contacts that contactor operating coils 1 and 1*A* are energised initially. When further pressure on the pedal opens contact 4, these coils remain energised through contactor interlock 1. Should the driver move the reverser while holding the control pedal depressed, the contactors will drop out as the handle passes through "off" and the reverser interlock opens, and they will not reclose until the pedal has been released fully so as to close master controller contact 4. This arrangement prevents reversal of the motor under power and ensures that after reversal the correct sequence through the resistance steps is followed automatically.

During our visit to the works, a variety of delivery vehicles and mobile shops incorporating the parallel/series battery control system was noted under construction, including some for Canada adapted for a standing driving position. This customer is conducting a road safety campaign in the form of slogans on the back of vehicles, and these have been designed and painted on the rear doors by Smith's Delivery Vehicles, Ltd., during manufacture at Gateshead. The factories also produce refrigeration equipment and other fittings for mobile shops, which are supplied normally with petrol or diesel chassis.



		CONTACTORS						MASTER CONTROLLER CONTACTS				PUSH BUTTON CONTACTS	
	STEP	1	1A	2	3	4	5	1	2	3	4	A	B
	OFF										●		●
PARALLEL	1	●	●					●			●		●
	2	●	●	●				●	●				●
	3	●	●	●	●			●	●	●			●
SERIES	T	●	●		●	●		●	●	●		●	
	4				●	●	●	●	●	●		●	
	5			●	●	●	●	●	●	●			●

Fig. 4—Control scheme using parallel/series switching of two battery sections



NOTCH	CONTACTORS			
	1	2	3	4
OFF	●			
1	○	●		
2	○	●	●	
3	○		●	●
4	○	●	●	●

Fig. 3—Power and control circuits of battery-electric tractor with battery cells permanently in series

DIESEL ENGINEERS AND USERS ASSOCIATION.—At the Annual General Meeting of the Diesel Engineers and Users Association, held on October 15, Mr. J. Calderwood, M.Sc., was elected president and Mr. Julian Tritton was appointed honorary secretary, and Mr. D. S. Dodsley Williams was appointed honorary treasurer.

SHORTER REPORTS

Human Problems in Marine Engineering

ON Thursday afternoon, November 26, Mr. C. C. Pounder read his paper " Human Problems in Marine Engineering " before a joint meeting of The Institute of Marine Engineers and The Society of Naval Architects and Marine Engineers held in the Memorial Building, London, E.C.3.

In the paper the author is more concerned with the impact of engines upon engineers than with engines, and reviews the more important steps in the evolution of the engine over the last century, together with the factors in the contemporaneous decline of sail. Later, current problems are outlined and evaluated from the point of view of the author who has been responsible for the design of many machinery installations.

The various methods used for navigation over the ages range from the coracle, ships with banks of oars, ships with oars and sails to the highly complex sailing ship, all of which are stated to have been subject to the limitations imposed by human muscles and sinews. A century ago the introduction of mechanical power for propulsion broke these limitations and also, to some degree, lessened physical drudgery although there remained that of handling coal and ash. The latter, according to the paper, was removed with the introduction of the diesel engine coupled with the burning of oil fuel under boilers. The transition from wood to iron and then to steel for hull construction is remarked upon and notes given upon the developments of machinery during the century together with particulars of one ship built in each decade up to the present time, all of which serve to summarise progress. Certain points in the evolution of machinery, as instanced by specific installations, are considered in more detail and cover the range from the simple expansion engine and boilers having a working pressure of 18 lb per square inch to four-crank triple expansion engines, geared turbines and pressure-charged diesel engines of high power. General arrangement drawings of several ships are included and also a chart which sets forth the life history of the White Star fleet from 1871 to 1930 and epitomises progress during that period.

Turning to current problems the author considers that if the trade unions which originally fought for the decencies of life have now become tyrants it is in accord with the pattern of human experience, and looking to the future the author feels that if there was a movement to the " Left," with the wrong men in charge, a vast bureaucracy would arise to stifle initiative and introduce another Dark Age. On the other hand should mechanisms develop to an extreme pitch there would be little to interest and the only initiative required would be that necessary to press a button. Nevertheless the author feels that as long as there was response to challenge, civilisation would advance. The paper states that economic necessity was responsible for the adequate supply of engineers in earlier days, whereas to-day amenities ashore, coupled with the demand for marine engineers for shore jobs, means that men are no longer attracted to a sea-going life. This trend has to be accepted as a social change and the planning of machinery and its controls must take into account the new order of things. Some remarks are directed to persons in high places and the qualities which inspire staffs, who in turn lend strength to leadership. The dangers of adulation are mentioned as is the value of experience which often prompts from below the threshold of consciousness.

The designing of machinery is stated as being an art and a science and the achievement of the maximum of practical results using the minimum of theoretical knowledge. Nevertheless, the design has to achieve an objective despite the limitations imposed by the raw materials of construction. The author believes that now marine engineers are of a stature equal to any in a shipping company and well able to play their part in the board room. In the development of new machinery the author defends the need for design modifications and replacement and refuses to consider such needs as mistakes. Engineers will continue to devise new prime movers since the world depends upon continuing progress, progress which contributes to material advancement as exemplified by the expansion of international trade, which has resulted from the introduction of power and has contributed to the raising of the standard of living throughout the world.

Bridge Over River Don at Doncaster

THE new bridge over the River Don at Doncaster officially opened by H.R.H. the Princess Royal on November 27, has been named St. Mary's Bridge. The new bridge is a balanced cantilever three-span welded steel structure supported on concrete piers and abutments, having a central span of 61ft and side spans of 34ft. It is built on a 77 deg. skew and carries 22ft dual carriageways with a 6ft central dividing strip and two 10ft footpaths.

Foundations of bored concrete piles, 18in diameter and about 30ft long, bear on soft red sandstone. In each abutment there are eighty piles and in each pier sixty, and most piles were driven with a rake of 1 in 10. The piers and abutments are formed of reinforced concrete, faced with York stone battered at 1 in 23·3in alternate 8in and 12in courses.

Ten welded steel girders form the bridge superstructure ; they are spaced at 7ft centres and stiffened by cross girders. This spacing provides for two parapet girders, a girder under each of four kerbs and two under each carriageway. There is a slight curve on the main girder soffit. The main girder is 2ft 11in deep overall with $\frac{1}{2}$in and $\frac{5}{8}$in webs and $1\frac{1}{4}$in flange plate 18in wide of notched ductile steel at the centre. There are rocker bearings on the centre span and the piers.

The main bridge girders were prefabricated and the cross girders site-welded. All site welding was checked by magnetic crack detection, and workshop welds were inspected by gamma radiography, a radiograph being produced of each main weld. Decking consists of 9in thick reinforced concrete slabs spanning the main bridge girders. A hot rolled asphalt surface was laid on the carriageways, applied in two layers of $2\frac{1}{2}$in and $1\frac{1}{2}$in consolidated thickness, and $\frac{1}{2}$in precoated chippings were rolled into the top layer. The services, comprising a 21in gas main, a 15in pumping main, a 9in water main, electrical services, and a twenty-four-way G.P.O. cable, are carried in ducts beneath the footpaths and central dividing strip. These services are packed in sand and the ducts paved with $2\frac{1}{2}$in precast concrete flags.

A roundabout with 185ft major axis and 110ft minor axis was built in conjunction with an improved northern approach to the new bridge. Carriageway approaches, constructed on filled or otherwise poor ground, consist of a 15in lean concrete base, on which was laid a 12in doubly reinforced concrete slab. A twin concrete box-section flood relief culvert 330ft long supported on concrete piles was also built.

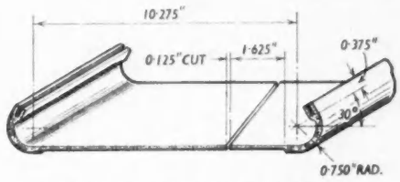
The scheme was designed and constructed under the supervision of Doncaster C.B.C.'s surveyor, Mr. M. Cawley, M.I.C.E. The contractor was Holland and Hannen and Cubitts (Great Britain), Ltd.

[Reply Card No. E7492]

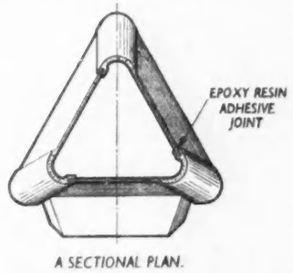
Aluminium Columns for Streetlighting

A STREETLIGHTING installation consisting of fluorescent lamps on aluminium columns of new design was inaugurated recently in Kempston Urban District, near Bedford. It is a Class " B " lighting installation (" Non-Trunk " roads) and consists of 450 15ft lighting columns.

Each column has a triangular cross-section



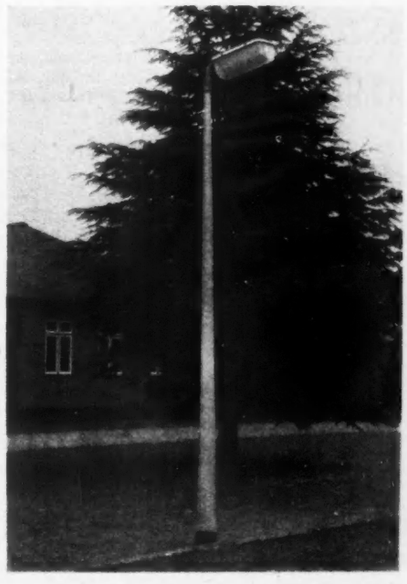
DIAGONAL CUTTING OF THE EXTRUSION.



A SECTIONAL PLAN.

Constructional details of 25ft aluminium streetlighting column

tapering from top to bottom and is built up of three HE9-WP aluminium alloy channel extrusions with 60 deg. inclined flanges as shown in the drawing. The upper view depicts a short length of an extrusion. By making a diagonal saw cut, as indicated in the top view, each extrusion yields two tapered lengths. From three extrusions six such lengths can be cut and two columns can be fabricated by interlocking the extrusions as shown in the lower drawing ; a cold setting epoxy resin provides a strong bond at the joint.



" Residential " lantern on " Leader " 15ft aluminium column

The tapered part of the column ends at a height about 3ft above ground level where it is bonded to a die cast base cap. Below this base cap is a parallel-sided housing for the lamp gear. The housing is of triangular cross-section and is pressed from NS4-¼H sheet with an interlocking folded joint.

A similar method of construction is used for 25ft columns designed for Class "A" (Trunk Road) lighting. The main difference is that the 25ft column is made in one piece about 28ft long from spigot to base plate. On the 25ft column the door of the auxiliary gear chamber projects slightly and increases the overall cross-section dimensions as can be seen from the sectional plan; this drawing relates specifically to the 25ft column, but (apart from the differences in the base and gear chamber as mentioned above) it applies to the 15ft column as well.

Lightness and strength combined with resilience are among the main attributes of this design of aluminium column. The 15ft column weighs 34 lb and can be carried easily by one man. Two men can excavate a hole and erect a column in about ten minutes.

The columns are very resilient to accidental damage from moving vehicles. One 15ft column was accidentally struck by a heavy farm vehicle and then by design was struck on two occasions by a refuse lorry; after the column had been bent to nearly 45 deg. it returned to about 80 deg. and remained effectively fit for service. During our tour of the Kempston installation we were shown a column which had suffered five impacts of this kind and was still capable of being pushed upright and kept in service until a convenient time for removal and replacement.

The installation at Kempston was carried out by the A.E.I. Lamp and Lighting Company, Ltd. Each of the 450 lighting points in the Class "B" installation consists of an A.E.I. "Residential" lantern containing two 40W, 2ft fluorescent lamps mounted on a 15ft "Leader" column of aluminium alloy. A.E.I. columns of this design recently won the first award in a design competition, for 25ft and 15ft columns, organised and sponsored by the Aluminium Development Association.

[Reply Card No. E7493]

Light-Alloy Radio Towers

THE use of aluminium for radio towers reduces maintenance and facilitates erection by the lightness of the parts to be assembled. Two towers of light aluminium alloy have been designed and manufactured for a government department, for installation overseas, by Saunders-Roe Structures, Ltd., Cowes, I.O.W., a subsidiary of Saunders-Roe, Ltd., and a member of the Westland Group of Companies. They are believed to be the first of their kind to be designed fundamentally for aluminium construction.

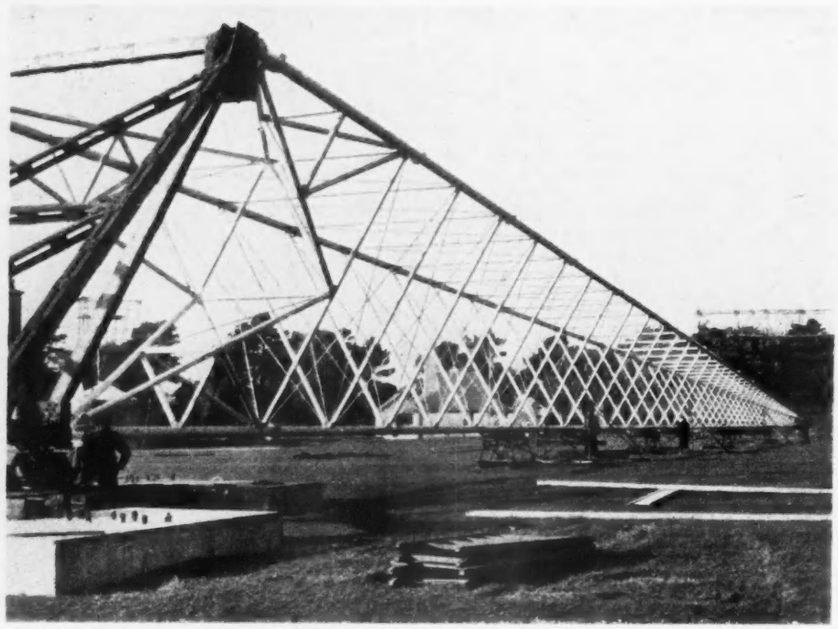
The towers serve as mast radiators and have a cylindrical top member which can be adjusted in 2ft steps to tune the structure to match the final detail characteristics of the transmitting installation. The smooth cylindrical form of the member, seen in one of the accompanying illustrations, reduces the tendency to corona discharge set up by the high voltages at this point.

In designing the mast it was desired to use the least amount of aluminium possible and to minimise drilling. The 20ft sections, formed of tubes of HT30WP alloy, are joined by a manacle joint designed specially for this purpose, comprising a clamp embracing collars screwed on to the enlarged ends of the tubes. Extrusions are of HE30WP alloy. Those for anchoring the bracing are welded on to the main tubes.

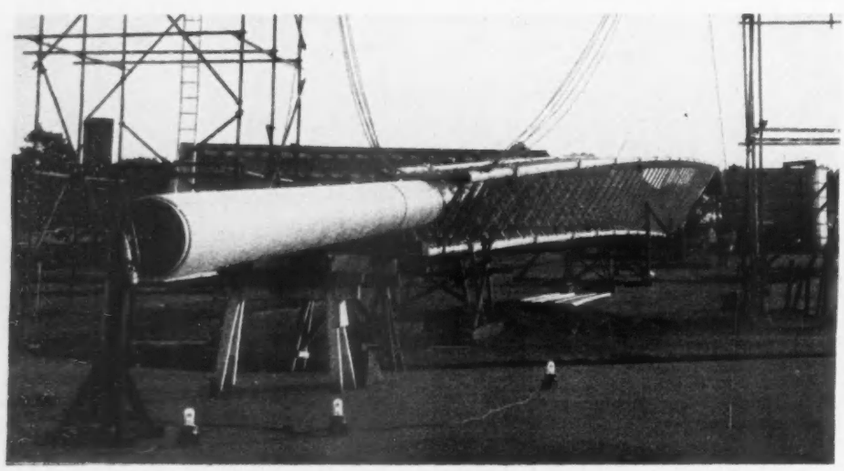
The towers are each 366ft high when the 20ft tuning cylinders are fully extended. Each side of the triangular base of the tower is only 20ft. The diameter of each of the tubular legs at the base measures only 7¾in, graded to 5in at the top, and the total weight of a complete tower excluding the three insulators on which it stands, is less than 7 tons. Provision is made for jacking the base so that insulators may be withdrawn if necessary.

To make a preliminary practical study of erection problems, the first tower was erected in two parts. Although the erection crew had had no experience of light-alloy structures, the work proceeded without difficulty, the light weight of the components contributing considerably to the simplicity of the operation. An interesting characteristic of this design of tower is that its own weight provides the same bending load of 6–6½ tons as that applied by the wind it is designed to withstand (70 m.p.h.). This has enabled the unusual test method illustrated to be adopted, one of the towers having been assembled lying on its side and then jacked up at the base clear of the supports so that it was, in effect, a cantilever over 300ft long. This provided an easy method of measuring deflection and studying general behaviour under load. The deflection recorded in these conditions was 6·2ft.

[Reply Card No. E7501]



Radio tower assembled horizontally on its 20ft base for load tests by jacking clear of supports



Top of tower showing cylindrical portion adjustable for tuning

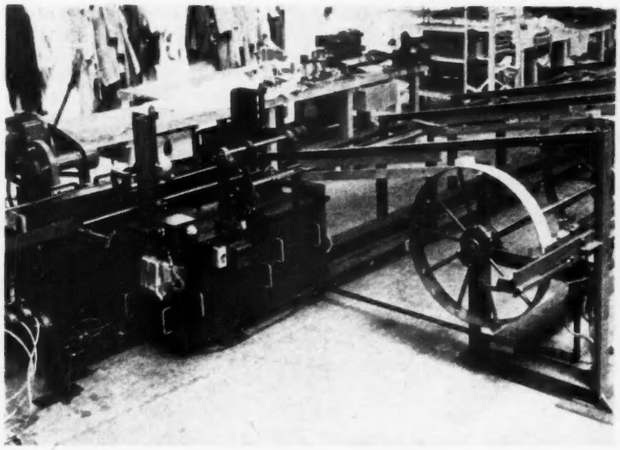
Plastics Vessels for Chemical Plant

A NUMBER of process towers and storage tanks are being fabricated in a new dual-laminate plastics material by Crawley Plastics, Ltd., New Haw, Weybridge, Surrey, for a chemical manufacturer. The material used is known as "Tufplas," and is a combination of Bakelite "Vybak" rigid p.v.c. sheet bonded to a polyester resin/glass fibre laminate. In completed structures, the internal p.v.c. sheet facing gives a high degree of chemical resistance, while the bond between the two components ensures that all of the loads on the internal surface are transferred to the structural reinforced polyester laminate. The bond also enables the laminate to withstand high temperatures.

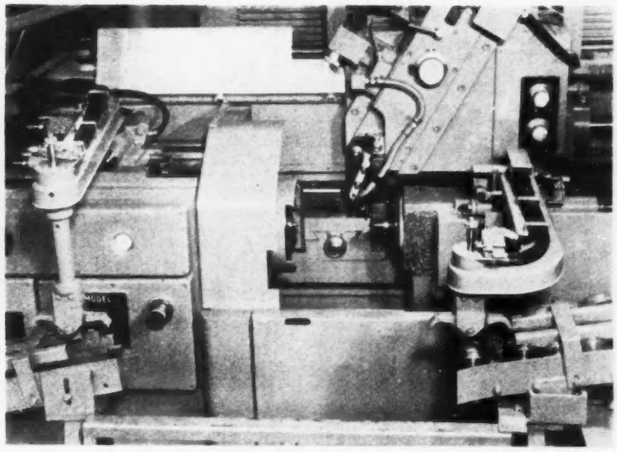
The thickness of "Vybak" used is at least ⅛in while that of the polyester laminate is determined by the stresses which will be imposed on the finished structure. Thus in storage tanks a fairly thick laminate is used near the base, where the load of contents is greatest, and the section is progressively reduced towards the top of the tank. It is stated that plant made from the dual laminate weighs only about one-fifth that of similar structures made from rubber- or p.v.c.-lined mild steel, whilst the strength and load-bearing characteristics are similar.

The order includes a 6000-gallon storage tank for highly concentrated bleaching chemicals, and this tank with a total weight of ½ ton is 20ft high by 8ft diameter. A 24ft high 6ft diameter process tower being supplied weighs only 600 lb and each of its four sections can be easily handled by four men. Two grids in this tower will carry a total weight of 4 tons of packings.

[Reply Card No. E7502]



Hydraulic-pneumatic equipment for preparing condenser tubes from drawn stock



Automatic loading and unloading mechanism fitted to a Churchill-Redman " P.5 " lathe

Condenser Tube Preparation Machine

An equipment has been designed and built by the Hymatic Engineering Company, Ltd., Redditch, Worcs, to the order of the Birmingham Battery and Metal Company, Ltd., for the preparation of condenser tubes from drawn stock. The operation of this machine is effected largely by hydraulic and pneumatic equipment, and although in this particular case a degree of manual control is involved it is stated that a fully automatic control system could be readily applied.

The new equipment is designed to receive tubing from ¼in to 1in diameter directly from a reeling machine, detect flaws, saw tubes to length, de-burr the ends, blow the swarf clear and feed the finished tubes to a transit stillage. Under the system devised, thin wall condenser tubing is straightened in a reeling machine and pulled by a withdrawal arm into a channel to be seen on the extreme right in our illustration. Wheels fitted with wooden pads raise the tube from the channel and deposit it on inclined rails down which it gravitates into a storage magazine.

From the magazine the tubes are fed one at a time by rollers into a " Teledicter " flaw detector, which, when a faulty tube is detected, automatically stops the feed and illuminates a signal lamp. Faulty tubes are removed by hand and the equipment re-started by the operator. The flawless tubes pass from the detector into a receiving channel whence they are transferred and clamped on vee-blocks in the end-sawing section of the equipment. For this end-sawing operation two circular saws are used, and one of these saw heads can be adjusted longitudinally to enable tubes from 5ft to 30ft long to be cut.

After a tube has been cut to length it is transferred to a de-burring station where its ends are cleaned and the swarf blown clear from the bore. From this station the tubes are discharged into stillages for despatch.

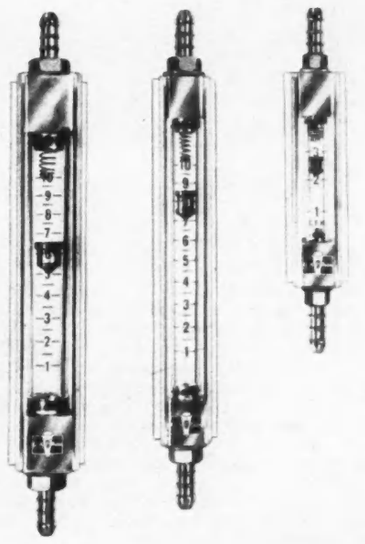
[Reply Card No. E7511]

Flow Meters

Three sizes of flow meters for gases and liquids being made by G. A. Platon, Ltd., 323a, Whitehorse Road, Croydon, Surrey, are suitable for typical installations with air flows from 0·1 to 200 cubic feet an hour and water flows from 0·5 to 60 gallons an hour. These " Gapmeters," as they are known, are designed for vertical mounting in the gas or fluid line, and are available with ⅛in, ¼in and ⅜in B.S.P. connections.

Three standard meters of this design are shown in our illustration. Each consists of a backplate with a precision-bored, tapered, glass tube mounted between end blocks. A calibrated scale is clearly marked up the length of the glass tube and the rate of flow is indicated by the level of the top of a float, raised in the tube by the passing liquid or gas, in respect to the graduations. A transparent plastic cover clipped over the instrument protects the tube from accidental damage.

Three standard forms of floats are available for each size of tube in the range, a hollow red-anodised duralumin float being used for low pressure gases ; a hollow stainless steel



Group of flow meters for gases or liquids

float for liquids and gases ; and a solid stainless steel float for liquids. These floats are fluted so that they are rotated by the flowing liquid or gas and a stainless steel spring stop is fitted at the top of each tube.

[Reply Card No. E7512]

Automatic Loading Equipment for a Lathe

A fully automatic component loading and unloading mechanism is now available with the " P5 " multi-tool and profile turning lathe made by Churchill-Redman, Ltd., of Halifax. A lathe fitted with this equipment can be seen in the illustration, where cluster gear blanks are being machined in a transfer line. The mechanism has a hydraulic and electric control system linked with that of the machine. It comprises a pivoted loading arm fitted on the machine tailstock and a similar unloading arm on the top of the headstock. Each arm has power-operated work-gripping jaws at its end and is designed to swing in an arc between the appropriate component conveyor and the lathe working position.

In the sequence of operations the loading arm jaws grip a blank in the input conveyor and the arm swings into the machine. The tailstock then advances, moving the component into open chuck jaws which close. The gripping fingers then open and as the loading arm returns to its position over the conveyor, the machine cycle starts. At the completion of the machine cycle, the unloading arm swings into the machine and its jaws close on the component ; the tailstock retracts and the chuck jaws open. The arm then moves to extract the component from the chuck jaws and swings outwards to the unloading station. The jaws open to drop the component in a gravity conveyor down which it rolls into an elevator where it is lifted to run down the input conveyor to the next machine.

If required, the automatic loading equipment can be isolated for the machine to be operated independently, sufficient space being available between the conveyors to give ease of access. When a gate in the gap between the conveyors is opened the loading mechanism is rendered inoperative.

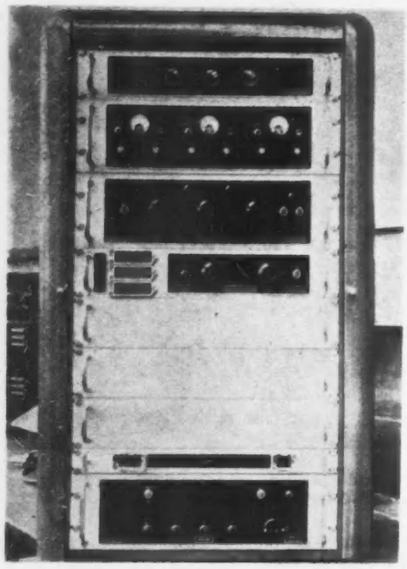
The loading and unloading units can easily be made to accommodate a variety of components and, as separate arms are used for loading and unloading, a component which varies considerably in shape before and after machining can be handled. The unloading arm jaws can also be made to pivot through 180 deg. so that the component can be placed on the outgoing conveyor in any desired position for handling on the next machine.

[Reply Card No. E7513]

Multi-Channel Millivolt Recorder

We have received from Southern Instruments, Ltd., Frimley Road, Camberley, Surrey, details of a multi-channel digital millivolt recorder for which the company is distributor. The recorder is manufactured by Bristol Aircraft, Ltd., and has been produced for making measurements in multiple installations of resistance strain gauges, thermocouples and other transducers of similar output. Its operation was described recently in a paper read by Mr. G. P. Tonkin, of Bristol Aircraft, Ltd., to the British Institution of Radio Engineers. The instrument is basically a digital potentiometer in which resistances are successively paralleled by relays to modify the current in a standard resistor and hence its potential difference. This process progresses automatically until balance is detected, when the relay state is transferred into a store.

Three separate digitising channels are employed in series-parallel to give a speed of twenty-five characters per second at a Creed Type 25 tape punch, or ten characters per second with a simultaneous typed record on an I.B.M. electric typewriter. These units may be used separately or simultaneously. Alternatively, single chosen channels can be brought out on a visual figure display. This is given by three " Nodistron " tubes, each containing the figures 0–9 superimposed in filamentary form. A selected figure is made visible by a glow discharge and fills the viewing window so that the display is conveniently visible from a distance. The equipment



Rack assembly for recording measurements in multiple installations of strain gauges and similar transducers. A visual display is given by the tubes in the top panel

can be provided with inputs as multiples of seventy-two channels with a maximum sensitivity corresponding to 15mV full scale at 200 ohms source impedance. The resolution is 1 part in 1000 of full scale.

The equipment is rack-mounted in the bench-top cabinet illustrated, which measures 3ft 6in high by 2ft wide by 1ft 9in deep, and weighs 280 lb.

[Reply Card No. E7514]

Heavy Plastics Protective Coatings

THERE has now been commissioned by Durable Plastics, Ltd., Woodbridge Industrial Estate, Guildford, Surrey, a plant able to apply plastics coatings to metal objects up to 5 tons in weight and 17ft by 7ft by 7ft in size. This plant, believed to be the largest in Europe, opens up the possibility of using coatings such as polyvinylchloride in place of rubber, thereby reducing the content of hand work, on large-scale equipment.

The firm is also equipped to deposit various other materials, including p.t.f.e. (polytetrafluoroethylene) and p.t.f.c.e. (polytrifluoromonochloroethylene). The characteristics of the principal plastics used are shown in the table below, which was abstracted from a brochure giving fuller details of the factors governing choice of material.

Locomotives for Ship Canal Railway

Two diesel-electric locomotives are now in service on the railway system of the Manchester Ship Canal Company. The company owns 230 miles of track, on which traffic has been worked hitherto by seventy-four steam locomotives. A detailed survey of operating conditions and requirements was accompanied by the study of alternative forms of diesel motive power, and as a result the choice was made of electric transmission in locomotives developing 400 h.p. and weighing just over 50 tons.

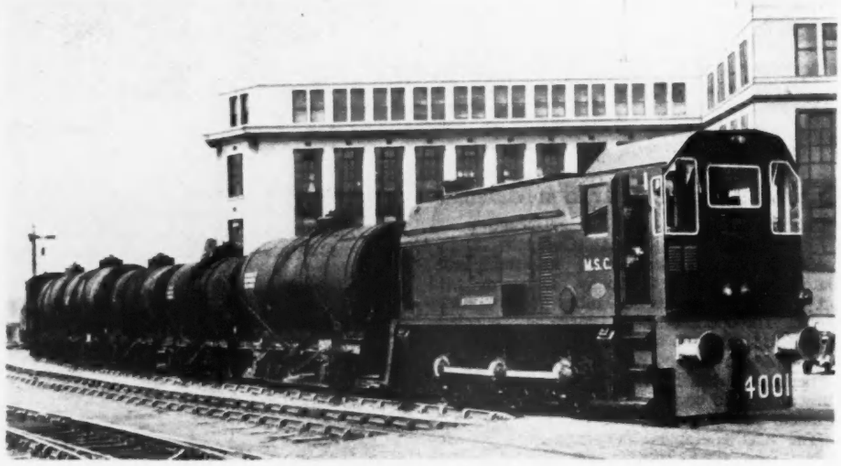
We illustrate one of the first two locomotives ordered under this diesel-electric programme. They have been designed and built by Hudswell, Clarke and Co., Ltd., Leeds, in close collaboration with the Traction Division of the Brush Electrical Engineering Company, Ltd., Loughborough, to the requirements of Mr. C. H. Gibson, the mechanical engineer of the Canal Company. The engine is a National R4AA6 six-cylinder normally-aspirated vertical four-stroke with a continuous rating at n.t.p. of 400 b.h.p. at 750 r.p.m. A single-bearing main generator is solidly coupled through a barring disc, with fan for self-ventilation attached, to the engine crankshaft. The auxiliary generator is belt-driven, but electric drive is used for the traction motor blower and a relay prevents power from being applied to the traction motors unless the blower is operating.

The two axle-hung, nose-suspended traction motors have a one-hour rating of 150 h.p., 429V, 290A, 873 r.p.m., and drive the outer of the three coupled axles through double-reduction gear trains with intermediate shafts extending the width of the machines. Coupled wheel diameter is 4ft 6in. The motors are connected in permanent parallel, and the locomotive is controlled by short-circuiting resistances to increase generator excitation on initial movement of the controller handle (while the engine runs at 400 r.p.m.) and then accelerating the engine through a direct mechanical linkage to the governor. Controls are duplicated for driving from either side of the cab. All the control equipment, except the resistance unit, is in the cab control cubicle.

Auxiliary machines comprise a Westinghouse D.H.16 compressor, and an Electrical Power Engineering motor for the blower. These machines, and charging current for the 92 a.h. D.P. battery, are supplied at 90V from an auxiliary generator controlled by a Newton automatic voltage regulator.

The locomotive weighs 51 tons 1 cwt in working order. Tractive effort ratings are 34,000 lb maximum and 16,000 lb for one hour. Maximum speed is 18 m.p.h. On a test run the first locomotive hauled 464 tons up a 1 in 40 gradient at a minimum speed of 6 m.p.h., at which the generator current was 675A. The one-hour rating of the generator is 249kW, 429V, 580A, 750 r.p.m. Further runs demonstrated the ability of the locomotive to improve on the specification requirements of hauling 700 tons on the level at 8 m.p.h. and starting with that load on a 1 in 100 grade.

[Reply Card No. E7522]



One of the first two diesel-electric locomotives introduced in replacement of steam motive power on the Manchester Ship Canal railway

General Data of Coatings

Coating	Safe working temperature, deg. Cent.	Maximum processing temperature	Volume resistivity at 200 deg. Cent., ohm cm	Possible thickness of deposit, inches	General chemical resistance	Oil resistance	Abrasion resistance	Toxicity	Inflammability	Shore hardness	Surface finish	Colour	Applied by :
P.V.C. "Vylastic D"	−50+95	170 deg. Cent.	3×10^{9}	0·01 to 0·45	Fair—Slight hardening. U/s for solvents*	Fair	Good	Very slight	Will burn	40–50	Gloss	Black*	Dipping
P.V.C. "Vylastic R"	−40+100*	170 deg. Cent.	3×10^{9}	0·01 to 0·4	Good—U/s for solvents*	Good	Very good	Very slight	Self extinguishing	60–70	Gloss	Full range	Dipping
P.V.C. "Vylastic S"	−40+105*	190 deg. Cent.	4×10^{9}	0·015 to 0·4	Good—U/s for solvents*	Good	Excellent	Very slight	Self extinguishing	80–90	Gloss	Black*	Dipping or spraying
Neoprene S.A.6	−50+110	Ambient	10^{13} variable	0·005 to 0·125	Best for atmospheric corrosion—Good for salt water*	Excellent	Very good	Very slight	Will burn	75–80	Matt	Limited range	Spraying or brushing
Polythene L.D.	70+95	200 deg. Cent.	3×10^{17}	0·008 to 0·200	Very good—U/s for Trichlorethylene*	Fair	Fair	Non-toxic	Will burn	85	Gloss	Full range	Dipping or spraying*
Polythene H.D.	−80+120	250 deg. Cent.	10^{16}	0·008 to 0·100	Very good	Good	Good	Non-toxic	Will burn	90	Matt	Limited range	Dipping or spraying*
P.T.F.E.	−80+250	450 deg. Cent.	10^{17}	0·0005 to 0·006	Complete	Complete	Poor	Non-toxic*	Non-flammable	75	Matt	Natural Black, Green	Spraying
P.T.F.C.E.	−70+200	350 deg. Cent.	10^{16}	0·005 to 0·015	Exceptional	Complete	Good	Non-toxic	Non-flammable	97	Gloss	Clear	Spraying
Nylon R	−60+120*	250 deg. Cent.	10^{13}	0·008 to 0·045	Good for Tric. U/s for mineral acids*	Excellent	Excellent	Non-toxic	Will burn	95	Gloss	Limited range	Dipping or spraying*

[Reply Card No. E7521]

* Qualities marked with an asterisk are subject to variation in individual cases.

Industrial and Labour Notes

Unemployment

Unemployment in Great Britain in the last month or so has shown a tendency to increase. On November 16, there were 430,540 people registered as out of work, compared with 419,000 on October 12. The Ministry of Labour says that the increase was in the figure for " wholly unemployed." The number described as " temporarily stopped " on November 16 was 11,175, which was virtually the same as on October 12. Expressed as a proportion of the estimated number of employees, unemployment in November was 2 per cent, compared with 2·4 per cent a year earlier.

An analysis of the regional figures shows that unemployment among adults increased during November by 17,000 and among boys and girls it declined by 5000. In the five-week period ended November 11, the employment exchanges filled 181,000 vacancies. The number of vacancies notified to exchanges but remaining unfilled on November 11 was 245,000 ; that was 1000 less than in October.

Export Prospects

In its *Bulletin for Industry*, the Treasury discusses this country's export prospects in the immediate future. It points out that the United Kingdom's exports are now on the upgrade. Compared with 1958, they were 3 per cent down between January and March but 7½ per cent up between April and October.

The advance of world industrial production continued in the first half of this year, the biggest rise being in the U.S.A. European production in the first quarter was little higher than at the end of 1958 but there were rises in the second quarter, particularly in the United Kingdom and Germany. World trade, allowing for seasonal factors, did not quite maintain its rise in the first quarter, as although trade between manufacturing countries increased, their trade with primary producing countries fell. World trade as a whole, however, was rising again in the second quarter. Now, the *Bulletin* states, expansion is under way in nearly all the major industrial countries.

According to the *Bulletin*, the United Kingdom's exports in 1958, and so far this year, have followed roughly the trend in world trade. Last year, the United Kingdom's exports fell a little more in volume but less in value than the average for world exports. Largely as a result of much lower exports from the U.S.A., for the first year since 1950 there was very little fall in the United Kingdom's share of manufactures exported by main manufacturing countries ; the results for the first half of this year show that that position was maintained. This country's exports to North America, after rising in 1958 by 12 per cent in the U.S.A. and falling by 4 per cent in Canada, have expanded by 25 per cent this year. Sales to West European countries fell by 7 per cent in 1958 but have recovered this year, especially since the end of March. During the first nine months of this year, there were substantial increases in United Kingdom exports to Switzerland, Germany, the Netherlands, Denmark, Turkey, France and Italy. Exports to the overseas sterling area fell by 3 per cent in 1958 and further between January and March of this year ; in the succeeding six months as a whole, however, they approached the 1958 level though they were still about 8 per cent less than in the comparable period of 1957. Summing it all up, the *Bulletin* suggests that the prospects for United Kingdom exports in the remaining weeks of this year and in the early part of 1960 continue good in North America, are fair in Europe and are improving in the overseas sterling area. But there is a note of warning, for the *Bulletin* points out that much depends " on prices and other factors in our competitiveness in overseas markets."

Import Duty on Machine Tools

The President of the Board of Trade announced in the House of Commons last week that he had decided to accept the proposal of the Machine Tool Trades Association for discontinuing the arrangements for the remission of import duty on individual importations of machine tools, together with a reduction in the duty on them. The Import Duties (General) (No. 10) Order, 1959, Statutory Instrument, 1959, No. 1957, which took effect from November 25, reduced the duty on machine tools covered by tariff heading 84·45 (B) from 17½ per cent to 10 per cent *ad valorem*. No further applications would be accepted for the remission of duty under Section 6 of the Import Duties Act, 1958, on machine tools covered by this heading, unless they had already been ordered. The President of the Board of Trade added that, as a consequence of accepting the proposal, he had decided that arrangements for duty remission on parts for incorporation in machine tools being manufactured in this country, while being continued for the present, would cease at the end of 1960.

Problems of Shift Work

A conference has recently been held in London at which various problems arising from shift working in industry were discussed. The conference was arranged by the National Institute of Industrial Psychology ; it was attended by management representatives of several industries and research workers.

One of the speakers at the conference was Mr. J. Walker, of the Medical Research Council's industrial psychology research group. He mentioned a cable company where a three-shift system had been changed during the war, on account of transport and other difficulties, to one involving a sixteen-hour shift on alternate days. When the management and unions wanted to revert after the war to the old system, four-fifths of the workers objected because they valued the thirty-two-hour break so much ! Mr. Walker also described a system of day and night shifts alternating at weekly, fortnightly or monthly intervals. He said that absenteeism tended to be higher on the day shift but, when the change was monthly, it increased from week to week on the night shift and decreased steadily on the day shift. This, he claimed, suggested that night work gradually impaired fitness or inclination for work and that the fatigue of the night shift affected the first week of day work. Day shift output also tended to improve and was usually higher than that on night shifts. At one steel works, Mr. Walker reported, about three-quarters of the absence without permission was on a shift starting at 6 a.m., though absence with permission was spread more evenly over the three shifts. It was thought that an adjustment of the shift timings might help. Another speaker, from a car manufacturing firm, asserted that there were more accidents on the night shift, possibly because of fatigue and because there was less supervision than by day.

Constructional Work

The Ministry of Works has stated that constructional work to the value of £504 million was carried out in Great Britain by contractors in the third quarter of this year. That was £11,000,000 more than in the second quarter and £40,000,000 higher than in the first quarter. The value of new housing work in the third quarter has been estimated at £144 million, which was about 10 per cent above the figure for the comparable quarter of 1958. The increase was entirely in work done for private developers.

The Ministry says there was virtually no change in non-housing work done for public authorities and on private industrial building compared with the preceding quarter. There was, however, a slight increase in the amount of repair work done. At the end of October, there were 1,082,000 operatives employed by the construction industries, which was 16,000 more than in July. The provisional index number of the volume of production for the third quarter (1954=100) is 112, or nearly 6 per cent higher than a year earlier. Costs in October continued to be slightly below the 1958 level, the index of costs (1954=100) being 113 in the third quarter.

Iron Castings Production

Business in the ironfounding industry continued to show improvement in the third quarter of this year, despite the influence of annual holidays which is customarily reflected in the third quarter's results. The total output of iron castings in the third quarter was 802,000 tons, which was 8 per cent higher than in the comparable quarter of 1958, and only 76,000 tons below the output in the second quarter of this year.

Commenting on the results, the Joint Iron Council says they show clearly that the depression which developed in the second half of 1958 has been left behind. But, the Council adds, the industry still has some way to go before the record outputs of 1955, 1956 and 1957 are reached. The progress made in the third quarter, however, was more widely based than in the second, owing relatively less to the automobile section and more to other sections. The increased demand for castings has come from several industries in which business has improved this year, the steel industry, the building industry and public works being particularly prominent. The only section which has shown a significant reduction in iron castings output, compared with a year ago, is railway equipment. The output of castings for the engineering section, however, is virtually unchanged, which is partly explained by the continued weakness in demand for castings for ships' engines, boilers and other items of heavy capital plant.

Optical Measurement of Principal Stresses

FOR many years, photo-elastic techniques have been applied to the determination of stresses in models made of glass or transparent plastic, as well as in actual components coated with special lacquers. While such procedures can give the complete stress pattern, i.e. the amount and direction of the principal stress at each point as well as the shear stress, they require elaborate mathematics which effectively confines their application to the research laboratory. For industrial inspection, large-field instruments are available which make it possible to measure the local difference of the principal stresses and thus to determine the shear. This is quite valuable, e.g., in the glass industry, where the finished articles may be examined for any locked-up stresses remaining after annealing. However, with materials such as glass which have compressive strengths many times larger than their strength in tension, it is of great interest to know the actual stress values as well as their sign.

A convenient method for the direct measurement of the principal stresses has been developed by Dr. Acloque, of the St.-Gobain Glass Works, Paris. His instrument, which we illustrate in Fig. 1, is now being manufactured under licence

Fig. 1—Clinopolariscope for the direct determination of stress in transparent specimens

by Dr. Heinrich Schneider Optotechnische Fabrik, Bad Kreuznach, German Federal Republic (U.K. agent: Nonius, Ltd., 38, Beethoven Street, London, W.10).

In common with all other photo-elastic instruments, the Schneider-Acloque "Clinopolariscope," as it is called, is based on the fact that transparent materials which are optically isotropic when relaxed become birefringent under stress.

In the two-dimensional case, the difference between the refractive indices in the direction of the principal stresses is proportional to the stress difference (Brewster's Law):

$$n_1 - n_2 = \text{constant} \times (s_1 - s_2) \quad . \quad . \quad . \quad (1)$$

If polarised light is transmitted at right angles to the specimen, and therefore to the plane of the principal stresses, it is split up into two partial rays vibrating in the direction of the principal stress. The relative retardation which these rays experience will be proportional to the difference between the refractive indices, and to the thickness of the material:

$$\delta \propto (n_1 - n_2)d \quad . \quad . \quad . \quad . \quad . \quad (2)$$

or

$$\delta = Kd(s_1 - s_2) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where the constant K is usually expressed in units of "brewster" (1 brewster $= 10^{-7}$ square centimetres per kilogramme). For glass and many plastics K is about 2·5 brewster.

In equation (3), K and d are assumed to be known, while δ is obtained by measurement. The equation thus gives the difference of the principal stresses. In order to determine the individual values of s_1 and s_2, further equations are required which may be obtained by transmitting a beam not at right angles to the plane of the principal stresses, but at some other angle.

In the "clinopolariscope," two light beams are transmitted, one in the direction of either of the principal stresses, and inclined at an angle of 45 deg. to the normal. Fig. 2 shows

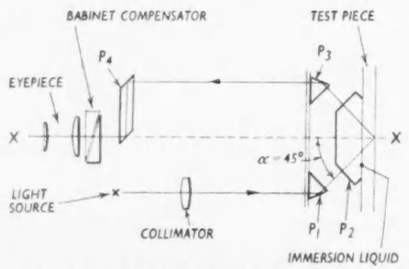


Fig. 2—Diagrammatic light path of one half of the system. The polarised beam enters the specimen and emerges under an angle of 45 deg.

diagrammatically the optical system for one of the beams, the other being identical but rotated through 90 deg. about the common axis XX.

The system consists of a light source and collimator giving a beam which is parallel to the axis. A prism P_1 deflects this beam through 45 deg. It then enters at normal incidence the prism P_2 which is in contact with the surface of the test piece, an immersion liquid being used to avoid internal reflection at the interface. The material of the prism has a refractive index similar to that of the test piece so that the light is not refracted from the 45 deg. path. After internal reflection from the rear surface of the test piece, the beam is returned along a path which is in all respects symmetrical to the forward path. Finally, the light is brought to the axis by a prism P_4 and the path difference of the partial rays measured by a Babinet compensator.

The principle underlying the measurement will be seen by reference to Fig. 3 which shows

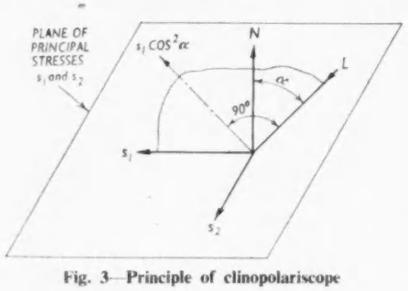


Fig. 3—Principle of clinopolariscope

a single beam L in the plane subtended by s_1 and the normal N and inclined at an angle α with respect to N. The two partial rays into which L is split vibrate in the mutually perpendicular planes (s_1, N, L) and (s_2, L) and are respectively retarded due to the effects of the component of s_1 at right angles to L (the component parallel to L having no effect), and s_2, which itself is at right angles to L.

The stress component of s_1 at right angles to L is equal to $s_1 \cos^2 \alpha$, and the length of the inclined path is $d/\cos \alpha$. Therefore, the relative retardation of the partial rays is equal to

$$\delta' = \frac{Kd}{\cos \alpha}(s_1 \cos^2 \alpha - s_2) \quad . \quad . \quad . \quad . \quad (4)$$

For a similar beam in the plane (s_2 N), the corresponding relative retardation is

$$\delta'' = \frac{Kd}{\cos \alpha}(s_2 \cos^2 \alpha - s_1) \quad . \quad . \quad . \quad . \quad (5)$$

Equations (4) and (5) may be solved for s_1 and s_2, giving

$$s_1 = \frac{\cos \alpha}{Kd(1 - \cos^4 \alpha)}(\delta'' + \delta' \cos^2 \alpha) \quad . \quad (6)$$

$$s_2 = \frac{\cos \alpha}{Kd(1 - \cos^4 \alpha)}(\delta' + \delta'' \cos^2 \alpha) \quad . \quad (7)$$

For an angle $\alpha = 45$ deg., these last equations reduce to

$$s_1 = \frac{0{\cdot}945}{Kd}(\delta'' + 0{\cdot}5\delta') \quad . \quad . \quad . \quad . \quad (8)$$

$$s_2 = \frac{0{\cdot}945}{Kd}(\delta' + 0{\cdot}5\delta'') \quad . \quad . \quad . \quad . \quad (9)$$

K and d being known, the principal stresses s_1 and s_2 can now be calculated from measurements of δ' and δ'' which in the "clinopolariscope" is carried out very simply by taking readings on a scale in the eyepiece.

The eyepiece field of view is divided into two halves by a central scale as shown in Fig. 4,

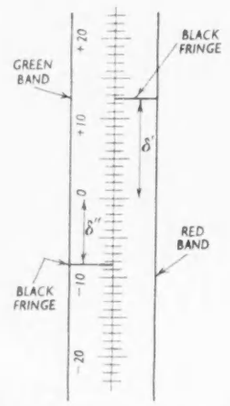


Fig. 4—Eyepiece field of view showing the central scale on which the positions (+ or −) of the interference fringes is read

one half being marked in green and the other in red. These colours refer to windows in the lamp housing which give the direction of the corresponding stress axes. A black fringe in each field marks the scale reading. Account must be taken of the correct sign, and readings must be multiplied by an instrument constant of 60 when substituting in equations (8) and (9).

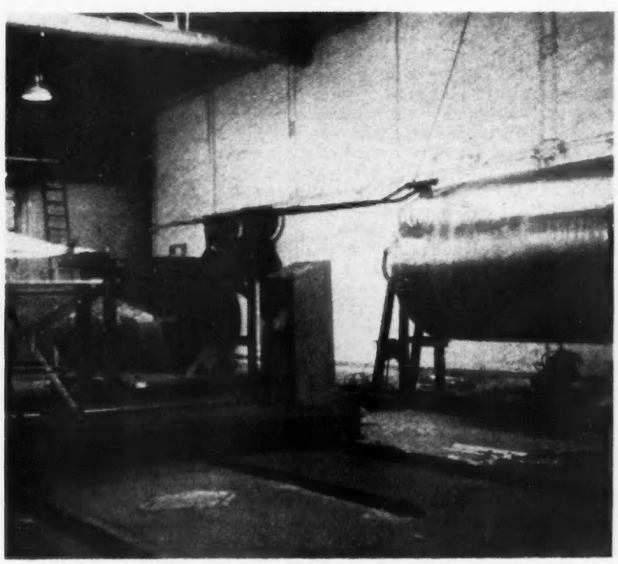
In using the instrument, two operations are necessary before taking a measurement. The instrument must be centred on the required point of the model and it must be oriented in the direction of the principal stresses. By operating a slide stop, a pair of crosswires can be brought into view which allow accurate setting of the position. Another slide stop switches on a central light beam which impinges on the model at right angles. The instrument is then rotated until the black interference line which appears in the right-hand half of the ocular field has reached its farthest distance from zero. This is the correct position with regard to the principal stress axes.

Glass Fibre-Reinforced Vessels

A special plant for the manufacture of tanks and vessels in glass fibre-reinforced plastics recently opened by a German firm is now producing lightweight tanks up to 2·5m diameter and 6m long. These corrosion-resisting tanks are stated to have consistent properties which can be determined prior to their manufacture.

ALTHOUGH it has been known for some years that vessels and components in many shapes can be produced cheaply in glass fibre-reinforced plastics, using a simple method of impregnating glass cloth or random fibre mat with hot or cold setting resins, it is now widely appreciated that in order to attain the high mechanical strengths possible careful control is essential at all stages of the manufacturing process. It is also essential in the course of manufacture to ensure that the fibres are fully protected against liquid attack in service, otherwise much of the initial strength of a vessel will be lost. To this end, a considerable amount of engineering research has been carried out, and, following extensive pilot scale development, Schwelmer Eisenwerke Müller G.m.b.H., Schwelm, Germany, recently started full-scale production of vessels. In this development work the firm has worked in conjunction with the British consultant, Dr. F. F. Jaray, of 6, Samsome Place, Worcester, who also collaborated in the design of the plant used. This plant is capable of producing cylindrical glass fibre-reinforced tanks up to 2·5m diameter and 6m long of some 30,000 litres capacity.

The new shop in which the plant is installed is air conditioned to prevent contamination of materials by dust and industrial fumes during tank manufacture and to maintain a constant temperature of about 20 deg. Cent. The cylinders are made on a winding machine which can be seen in the photograph we reproduce.



Cylindrical tank in glass fibre-reinforced plastic being formed on winding machine

The formers on which the cylinders are made are rotated between head and tail stocks on the machine, the headstock drive being from an electric motor through a variable speed gearbox. Normally the formers are rotated to give a winding speed of about 100ft per minute, but the speed of winding naturally depends upon the diameter, wall thickness, and other design factors of the tank cylinder being made.

The glass rovings used in manufacture first undergo a special surface treatment designed to ensure an efficient bond is made between the glass and resin in the forming stages. These rovings are wound on to spools or bobbins, of which up to 120 can be mounted on the spindles of the machine carriage. This carriage is mounted on rails set in the floor in front of and parallel with the former on the machine. A length of roller chain is anchored at each end in the floor midway between the carriage rails. This chain passes over the driving sprocket on the carriage and is held over the sprocket teeth by idler rollers each side. The sprocket is driven through variable speed gearing by a motor and the transmission is stated to give a constant steady traverse of the carriage along its rails in each direction of travel.

As the former is rotated in the cylinder making process it draws the rovings off their spools. The rovings then pass in the form of a converging band through a tank of resin on the carriage. A predetermined surplus of resin is removed from the rovings at the outgoing side of the tank and the band is then guided through a comb at the end of an outrigger arm on to the rotating former. The controls with this equipment are such that the impregnated rovings are deposited to a precise thickness and at an angle which has been determined by stress calculations in the design stages. If required the carriage and former speeds can be varied and the direction of carriage traverse changed, to apply additional thicknesses of rovings at any predetermined places on the former where a reinforced section of cylinder may be needed. Thus, by careful planning and the maintenance of a strict schedule during the forming operations, cylinders can be made to approximate closely design calculations without dependence upon operator's skill.

We are informed that tanks up to about 10,000 litres capacity are generally made from solid reinforced plastics. Larger tanks are to be made by sandwich construction which makes possible the use of greater thickness of the shell, ensuring much greater stiffness, and at the same time enabling a reduction in weight and cost.

When the necessary thickness of the cylindrical shell is reached the fibres are prestressed by expansion of the former. This procedure, in addition to assisting the wetting or bringing in contact of resin or glass, also gives advantages in structural formation. At the conclusion of the forming process, the former complete with the cylinder is removed from the machine, and subjected to a cure at predetermined temperature sequences so as to ensure optimum properties of the finished article.

The ends for cylinders are at present being made in large plastic moulds which have been taken as impressions from steel ends. In this process a predetermined number of unidirectional cloth layers are cut to size and placed in the female mould. The male mould is then inserted, the resin—generally of the cold curing type—is applied, after which the whole assembly is put under pressure. The finished and cured moulding is removed after approximately two hours when the moulds can be used again. With the surface preparation involved it has been found possible to use a set of moulds about three times per eight-hour shift. After trimming the close-fitting ends are inserted in the cylindrical shells and fixed by an adhesive bond.

The inner surface of each tank is treated so as to make it suitable for the character of the contents for which it is intended and at the same time to afford protection of the main fibre structure against liquid attack. The principle of this type of construction was described in an article in THE ENGINEER of December 14, 1954. A manhole cut into the end of each tank is reinforced with a pre-formed rim of glass fibre laminate. The manhole lid is formed by a similar pressing process to that used for making the ends and it is fitted with a stainless steel spindle for locking purposes.

Normally tanks of this construction will stand at least a temperature of 100 deg. Cent. and a 15 lb per square inch working pressure. Whenever higher temperature or higher pressure characteristics are required the practice has been to return a tank to the winding machine, and apply another number of layers of fibres in such a way that the ends are tied into the main reinforcement and give the finished product the required axial and radial strength.

It is stated that the production of a tank of 10,000 litres capacity with the equipment described takes approximately twenty to twenty-five man-hours. The two ends account for about 40 per cent of the total time and a machine is now being designed which will be able to make from rovings two ends at once—and by which the principle of prestressing is also applied.

The same basic method of construction is being used for rectangular tanks, and the process consists simply in winding a long tube of rectangular cross section of which suitable lengths are cut off to form the sides of vessels, and the winding of rectangular bottoms which are inserted and cemented to the outer shell. The properties of such tanks, it is claimed, are consistent and can be forecast, whilst the loss of strength of protected fibre glass structures is negligible and known in its amounts. With the winding techniques developed, which can also be applied to the manufacture of pipes, fibre glass has become a lightweight, corrosion-resisting engineering material of known properties. We are informed by Dr. F. F. Jaray that, since the above equipment was placed in service, a second plant has been installed at the works of Ateliers de Construction de Familleureux, Belgium for making tanks up to 3m diameter by 10m long.

Aluminium Log Flume

A log flume of welded aluminium sheet supported on a steel and concrete framework, about 6½km long and having a capacity of 25,000 logs per hour, was completed and taken into use recently at the 375MW Stornorrfors hydro-electric power station.* The design work and model tests, as well as the construction, were carried out by the Swedish State Power Board, while the sheet metal was supplied by AB Svenska Metallverken. The flume consists of 983 elements, each 6m long, and made up of five 1·2m long and 3mm thick sheets welded together. The flume sections rest on longitudinal steel box girders which in turn are supported by steel sections mounted on concrete sleepers. The sheet for each section weighs 90 kg, while the steel framework weighs 660 kg.

The gradient of the flume is practically constant over the whole of its length, and amounts to 1 in 100. A special erecting hoist used in the work travelled on the box girders as on rails and could lay on average ten sections a day, so that the whole of the construction could be completed in slightly over three months.

The sectional units were pre-assembled at Stornorrfors and transported to the site in crates holding five at a time. A rubber asphalt compound was used to seal the steel and aluminium parts together, and profiled synthetic rubber was employed for joining the overlapping aluminium segments to one another.

* See THE ENGINEER, December 12, 1958, page 941, for a description of Stornorrfors power station.

Large-Scale Nuclear Power Plants for Electric Utilities

By OUR AMERICAN EDITOR

As part of its activity in the field of atomic power, the Westinghouse Electric Corporation, of Pittsburgh, Pennsylvania, is continuously analysing the broad field of nuclear reactors to evaluate the status and potential of many different designs. From recently completed phases of this analysis and co-operative work with consulting engineers, three atomic power plant schemes have been identified as logical further steps for utility companies to take in their programmes of power generation from the atom. In two of these projects, it is now possible for the company to guarantee plant output, overall plant costs and fuel life—the principal factors which are not always under the complete control of the utilities.

Power Cost Trends

IT is appropriate to consider first a chart showing power cost to utilities in mills (1 mill =0·001 dollar) per kilowatt-hour as a function of time since 1900. The cost curve for fossil-fuelled plants from 1900 to 1959 is indicated as the band at the left in Fig. 1. From here it is predicted to be going up ; exactly how far depends on an individual situation. This curve can now be compared to the band on the right which, according to the U.S.Atomic Energy Commission, represents a prediction of the power cost curve for nuclear plants. Here again a band rather than a line is indicated because no one is quite

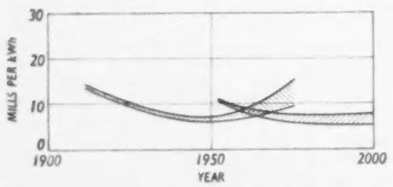


Fig. 1—Forecast of power generating costs with fossil-fuelled and nuclear-fuelled plants

sure how fast nuclear technology will advance. But, in any event, all available information indicates that atomic power costs will fall in the range indicated by the right-hand band.

Looking at these two curves together, one sees that somewhere they are going to cross. Where and when is a matter of individual economics and progress of the art. This all means that utilities must now consider where and when and how much to invest in their nuclear development if they are to continue to produce economical electric power. The answers to these questions will, of course, be related to their individual purpose in entering upon a nuclear reactor programme. Should the objective be to get a plant on the line as soon as possible, with the best economic picture to-day's technology can offer, or should one select a more advanced type that has good long-range possibilities ?

To provide the utilities with a sound basis for making these decisions, Westinghouse recently reviewed the current state of the nuclear art and summarised the current status of the major reactor concepts. It is believed that no one type of reactor will ever be the final answer for all utilities' needs. There are too many variables in designs, methods for extracting heat from nuclear reactors and in the economics and objectives of individual applications.

Important Reactor Concepts

The most " exotic " idea and the one, therefore, which seems farthest in the future, is that of power from thermonuclear fusion. It may well be into the next century before industry will be discussing with utilities the possibility of fusion reactors being employed for power generation. Until then, one must consider the fission reactor systems. One design is the thermo-electric reactor system, in which heat from fission is converted directly to electricity without the use of a conventional steam cycle turbo-generator. At present, the conversion efficiency of available materials is the limiting factor in the application of this principle. Recent research shows that the new mixed-valence compounds have the best efficiency for electric current generation. At present large power station thermo-electric units are not visualised, but these reactors should have application in satellites, missiles, or small remote stations.

In the category of fission reactor systems are the breeder reactors. Prototypes of one such reactor—the fast breeder—have been built and operated. Now under construction for the Power Reactor Development Corporation is a 100MW plant of this type. The operation of this plant will be the means by which it will be possible to assess the long-range potential of this reactor design. Another version of the breeder principle is the thermal breeder reactor, using either a solution or a slurry mixture which contains the fuel. The fuel-in-solution reactor, being developed by the Oak Ridge National Laboratories, uses a uranyl sulphate-acid solution. In the slurry-fuel reactor, a thorium oxide slurry circulates through a loop and fissions in a reactor section. The Pennsylvania Power and Light Company and Westinghouse have done considerable development work on this system. From the results of this work, the participants agreed that the construction of a prototype would be necessary before a decision could be made to proceed with a full-scale plant.

Another concept is the gas-cooled reactor, which can either employ the direct cycle or the closed cycle. In the direct cycle, the hot gas from the reactor is fed directly to a gas turbine. To date, some 20,000,000 dollars have been spent on research and development, and it is felt that an additional 30,000,000 dollars will need to be invested before this plant can be brought to a practical design. One of the technical difficulties encountered in this system is that of building reactors which operate above 1300 deg. Fah., the temperatures required to make this system operate. In the other gas-cooled system, the hot gas from the reactor is passed through a heat exchanger to produce steam, as in the Calder Hall reactor. It has the disadvantage of requiring very large heat exchangers because of the poor heat transfer characteristics of gases. Calder Hall uses natural uranium as the fuel, resulting in relatively low temperatures being produced. Enriched fuel systems and the consequent higher operating temperatures for this concept are now being investigated, however, by the High Temperature Development Corporation and by the United Kingdom Atomic Energy Authority.

The organic reactors are subdivided into the fixed and mobile fuel designs. The fixed fuel system is similar to the closed-cycle water reactors, wherein the coolant-moderator flows through the reactor and gives up its heat to a secondary system through a heat exchanger. The coolant and moderator is an oil or phenyl compound and, using it, the primary loop can be operated at much lower pressures for equivalent temperatures, as compared to water. Furthermore, oil is much less corrosive and allows the use of relatively thin ordinary carbon steel instead of stainless steel. Offsetting this highly desirable cost advantage is the fact that even the best oils have poor heat transfer characteristics as compared to water ; oil also decomposes under reactor conditions and has to be purified and replenished. An organic system showing definite promise is the mobile or fluidised bed system. In this arrangement the fuel is in the form of spherical capsules in the reactor vessel ; the coolant-moderator flows through the vessel and distributes the pellets evenly throughout the vessel. The coolant goes on to a heat exchanger and then back into the reactor vessel. This system has the distinct advantages of providing uniform distribution of fuel and burn-up and the fuel is easily removed or renewed. The reactor system is considered to be promising for smaller plants of 5MW to 100MW.

A reactor which uses heavy water as coolant and moderator has advantages in the ability to use natural uranium as fuel and the excellent moderating properties of heavy water. However, heavy water is expensive—currently about 30 dollars a pound. As a result, great precautions have to be taken to guard against loss of heavy water. A heavy-water-moderated reactor prototype that uses the " pressure tube design " is being developed for the Carolinas Virginia Nuclear Power Associates and will be running in 1962. The economics of this reactor design appear good in the 200MW size using natural uranium as fuel. Once the prototype is in operation it will be easier to determine whether the overall advantages of the concept offset the disadvantage of the high cost of heavy water.

The water reactors are the class with the most actual design and operating experience to date. The Westinghouse Electric Corporation particularly has obtained wide experience in this field, resulting from such projects as the " Nautilus " submarine propulsion plant, the Shippingport atomic power station and the new Rowe power station of the Yankee Atomic Electric Company. There are several variations of water reactors ; the first one is the closed-cycle or pressurised water reactor. In this system, water under pressure circulates through a primary loop, picking up heat in the reactor and giving it up in a heat exchanger to a secondary system that generates steam. This system has a wide range of application—from 1MW to 400MW. It is the easiest reactor to control and the most stable one that can be built. The second major variation of the natural water system is the direct-cycle unit, in which steam from the reactor is piped directly to the turbine. In one such reactor, called the direct-cycle natural circulation system, the incoming water passes through the reactor core, forming a steam-water emulsion. Steam-water separation is accomplished inside the reactor ; steam goes on to the turbine, is condensed and re-enters the reactor. The difference in density between the steam column in the core and the water column outside is sufficient to cause natural circulation in the steam-water loop. This system has excellent application in the small power ranges from 5MW to 50MW. However, because of water flow characteristics and steam separation problems, it takes a very large core to produce sufficient heat. To overcome this difficulty, one can use forced circulation of the water. This brings about higher nuclear efficiency and increases the hydraulic stability of the reactor. The capital costs are increased, but the range of this system is increased up to about 150MW.

The combination of the direct-cycle and the closed-cycle system is known as the dual cycle. In one leg of the system which is operated as a direct-cycle loop, steam is carried directly from the top of the reactor to the turbine and then back to the reactor after it condenses. Meanwhile, a second leg is operating on the closed-cycle basis with heat from the reactor being transferred first to a heat exchanger which generates steam for the turbine. In the direct-cycle end of this system the steam and water are separated outside the reactor ; this steam goes to the high-pressure end of the turbine. The lower pressure steam from the closed-cycle end enters the turbine in its low-pressure range. The power range of the dual-cycle plant is from 150MW to 400MW. This system has a higher power density than the other two but also involves higher capital costs. Furthermore it has the problem of a possible contamination of the entire primary system, including the turbo-generator unit. Since it requires a complicated

turbine and control system, this system increases in cost to the point where there is little difference between it and a straight closed-cycle plant.

For the larger plants it is important to determine which of these two systems has the greater present and long-range potential. To establish this comparison a number of parallel technical and economic studies have been made for closed-cycle and dual-cycle plants up to 300MW. The power costs for the closed-cycle and dual-cycle plants are essentially identical over the range of applicability. The saving in heat

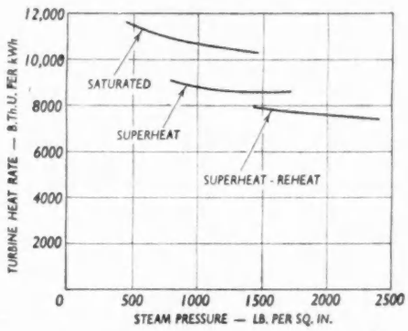


Fig. 2—Improvement in plant efficiency by the addition of superheat and reheat

exchanger capacity for the dual-cycle plant is almost offset by the reduction in piping and other components for the closed-cycle plant. Where economics are comparable, the choice clearly goes to the closed-cycle system, due to the advantages obtained in the important areas of operation and maintenance.

Of all these major reactor designs being considered, Westinghouse feels that the water reactors have the greatest promise of achieving competitive nuclear power soon. Several variations have been suggested to improve efficiencies and to reduce the mills per kilowatt-hour cost. One of the most important of these variations is the idea of superheating steam as it comes from the reactor to bring it up to modern turbine conditions. Fig. 2 illustrates the improvement in plant efficiency which can be obtained by the addition of superheat and reheat. Tnus, heat rate reductions of 30 to 35 per cent can be obtained by the use of high-pressure superheat-reheat cycles. Superheating constitutes an important step forward, and it plays a significant part in several recent reactor scheme developments.

The three new water reactor power plant schemes, which Westinghouse considers to hold the most immediate promise for the electric utility industry, are described below. Detailed overall designs for two of the plants have been worked out with consulting engineers, and for this reason specific economic and cost information can already be presented.

The Combination Plant.—The first new reactor scheme is called the combination plant because it uses both nuclear and fossil fuel. It meets the present need of utilities to obtain an economical way of investing in the nuclear power future. This plant was designed around a modern, presently available, turbine and the steam conditions it requires. The nuclear reactor and superheat-reheat system was then designed to meet these conditions. The turbine is rated at 225MW gross and can essentially be ordered "from the catalogues." The steam inlet conditions at the first stage are 1800 lb per square inch at 1000 deg. Fah., with reheat temperatures of 1000 deg. Fah. These steam conditions can be achieved using a direct-cycle system: a superheater using nuclear fuel could be designed for this purpose, but this second reactor would involve new problems and would be prohibitive economically. The most realistic solution was to use a fossil-fired superheater. In addition to superheating steam before it goes to the first stage of the turbine, the superheater is used to reheat steam to 1000 deg. Fah., after it passes through the first section, and before it is fed back into the second section of the turbine.

Fig. 3 shows the general operating principle and main components of the combination plant. In the core of the reactor, water circulates and boils at 2115 lb per square inch, dry and saturated. Canned motor pumps circulate the water through the core. A steam separating drum situated in the loop between the reactor and the superheater separates water from the steam and ensures that only steam is passed on to the superheater. The water collected at the separating drum is returned to the reactor cycle. The steam from the superheater at 1800 lb per square inch and 1000 deg. Fah. passes to the first section of the turbine. After passing through both stages of the turbine, the steam is condensed and returned to the reactor. The main dimensions proposed for this plant are as follows: The 34ft high reactor vessel is 9ft 3in in inside diameter, and its walls are 8in thick carbon steel with a ¼in stainless steel lining. The core of the reactor is fuelled with about 26½ tons of uranium fabricated into small pellets. This uranium is enriched to about 2 per cent.

The superheater with its auxiliary equipment is 146ft high and is 76ft by 65ft in rectangular dimensions. This superheater can be fuelled with either oil, gas or coal, the choice depending on the individual utility economics. Tne nuclear portion of the plant contributes about 300MW (thermal) and the superheater about 220MW (thermal) to the net power output of the plant. Together, they would produce an electric gross output of 225MW. The total net heat rate of this plant would be the best yet obtained from a nuclear plant—9040 B.Th.U. per kilowatt-hour.

Work towards the construction of this plant can be started immediately and, according to Westinghouse, it could be in operation four years from the date of the contract. Feasibility studies have indicated solutions to all the major

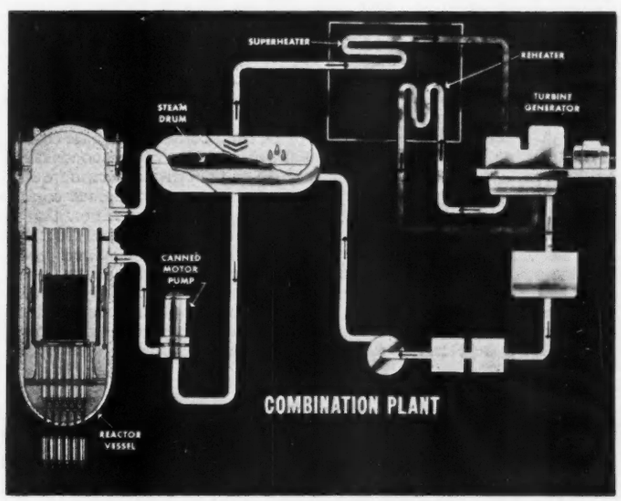


Fig. 3—General operating principle and main components of the combination plant

technical problems presented by this plant. In the area of control, for example, it was found that the 2000 lb per square inch open-cycle reactor would be easier to control than one operating at 1000 lb per square inch. As with any open-cycle plant, there is the problem of possible oxygen corrosion in the condensing stages of the turbine. But in this plant, studies indicate, because of the high initial reactor pressure and the superheat cycle, the oxygen concentration is only about 1 per cent of that in a 1000 lb per square inch dry and saturated steam plant. Finally, the question of controlling the reactor and superheater together appears to be difficult, but feasibility studies have suggested several solutions.

The economic considerations following are based on a 90 per cent load factor; a 12·5 per cent annual interest on capital investment; fossil fuel costs of 30 cents per 1,000,000 B.Th.U.; plutonium credit of 12 dollars per gramme; and 0·5 mills for indirect costs. Under these conditions, the direct-cycle nuclear power plant with fossil-fired superheat and reheat will produce electric power for 7·3 mills per kilowatt-hour. These costs break down as follows: 3·4 mills in capital investment; 2·7 mills for fossil fuel; 0·5 mill for indirect costs, and 0·7 mill for operation and maintenance. It is important to note that fossil fuel costs affect the total power cost estimates of the combination plant. Naturally, as fossil fuel costs rise, the economical advantage of this plant over totally fossil-fired plants will become less distinct. Specifically, at 40 cents per 1,000,000 B.Th.U., the power cost for the combination plant will rise to 7·7 mills per kilowatt-hour; at 60 cents to 8·6 mills per kilowatt-hour.

To-day, the all-fossil-fuelled power plant holds the economy edge over the nuclear plant in all but the highest fuel cost areas of the United States. How long it will be until the nuclear plant supplies the least costly power in every area depends on local conditions. In some areas the combination plant will win on a mills per kilowatt-hour basis over the lifetime of the plant. Therefore, until that time when the all-nuclear plant supplies the least costly source of power in every area, there is definitely a place for a combination plant scheme.

The Integral Boiling and Superheat Reactor Plant.—Tne fundamental superheat concept is responsible for the combination plant and leads to a second recommendation by Westinghouse to the utilities—the all-nuclear plant with integral superheating. In this so-called Integral Boiling and Superheating Reactor, the water is both boiled and then superheated within the reactor core. No separate unit for superheating is required. This plant is farther in the future than the combination plant; the firm envisages a full-scale plant of this design to be operating in 1975. The operating principle of such a reactor is shown in Fig. 4. A number of pressure tubes is inserted into the centre and around the periphery of the centre of the reactor, which is essentially a large block of graphite. Smaller rods holding the nuclear fuel are inserted into each pressure tube and between these small fuel rods there is enough room for the coolant water to flow. A carbon steel vessel, through which the pressure tubes extend, surrounds the core.

In operation, circulating water enters the central region boiling tubes and is rapidly heated as it passes through the fuel region. Tnis heated mixture of water and steam moves up to one of four steam drums situated above the reactor. The separated water is returned to the bottom of the boiling tubes in the central region of the reactor, while the separated steam flows into the upper end of the superheating tubes situated in the perimeter area of the core. The superheated steam collects in a header and then flows directly to the turbine. Within the carbon steel containment vessel and completely blanketing the graphite moderator in all its vital areas, is helium under a pressure of 100 lb per square inch. The helium will control the heat transfer from the graphite moderator to the pressure tubes, at the same time maintaining the graphite temperature within safe operational limits. The helium control is necessary since the graphite is hot; in fact, about 10 per cent of the reactor heat generation is performed by the graphite itself.

The integral boiling and superheating reactor is felt ultimately to provide a very economical,

efficient 200MW reactor. However, thorough research and development programmes coupled with the construction of a prototype plant must precede the full-scale 200MW plant. Control of the reactor will be a major problem, since within a few inches inside of the reactor, it will be necessary to handle temperature differences of nearly 400 deg. Fah. The answer to this heat control is expected to be obtained by detailed studies in the programming of the control rods. The reactor has already been designed with a large number of control rods to make this problem easier to solve.

Another aspect of the control problem concerns the flow of the water and steam through the two reactor sections. The two flows must be balanced and adjusted to meet the surge demands of the turbine. Fortunately, the pressure-tube design offers a ready solution. In the superheat section, there can be installed a throttle at the inlet of each tube and a thermocouple at the outlet. By coupling these units into an information feedback system, precision control of the reactor is possible. Although not constituting an insurmountable problem, several questions about fuel performance in the higher temperatures of the superheat section need to be answered. Here, again, prototype experience is necessary.

A final research and development problem concerns improving the pressure tubes. One can make perfectly satisfactory pressure tubes for this reactor, but if they could be made from a stronger metal which does not absorb neutrons excessively, the tube walls could be made thinner. For the superheating region tubes, two alloys, Discaloy and Inconel-X, are being examined ; for the central boiling region, there are the Zircaloy and AM-350 alloys. If one of these alloys proves suitable, substantial reductions in power cost would result. To solve these problems and to ensure the success of the eventual plant, it is hoped to build now a prototype plant just one-tenth the size of the final plant, of 20MW capacity. In this prototype plant, the graphite block is 11ft in diameter and 14ft high. Fifty-six pressure tubes will be situated in the central boiling area and twenty-four tubes in the superheat area. Each tube is 2·7in in diameter, and within each pressure tube there are nineteen fuel rods, each ½in in diameter and 10ft in length.

The containment vessel is 23ft high and 12ft 6in in diameter, made of carbon steel ½in thick. There are only two steam drums in this prototype system, each 11ft long and 4ft in diameter. The turbine for this prototype plant would operate at steam conditions of 850 lb per square inch and 900 deg. Fah. Naturally no such prototype plant can be economically competitive, but the building of the prototype will be a real contribution to technological progress because the integral boiling and superheating reactor concept promises good economy in the more distant future. Since this reactor is based on the pressure tube system, it is versatile and changeable and able to be adapted to later developments. Thus, it is considered to be the nuclear reactor that promises the most economy in the more distant future.

The 330MW Closed-Cycle Plant.—The above considerations regarding the long-range all-nuclear plant does not mean that a large, economical all-nuclear plant cannot be built for utilities to-day. The Westinghouse

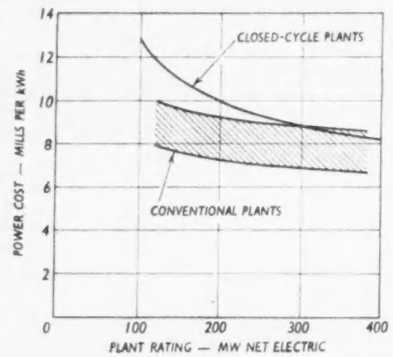


Fig. 5—Cost comparison of conventional steam power plants and closed-cycle atomic power plants

Electric Corporation is at present recommending the construction of a 330MW (electrical) closed-cycle, water-moderated plant. The philosophy behind this design is based on the facts that (*a*) there is economy in large reactors and (*b*) the closed-cycle plant is the most proved type to date. This recommendation is the result of a detailed study to establish the feasibility and economics of closed-cycle plants up to 400MW, with start-up to be early in 1965. All these plants were established as being feasible within this time scale. The economics of the larger ratings looked particularly promising. They were so promising, in fact, that a comparison was developed with conventional plant costs in the medium to high fuel cost areas of the United States. This comparison is shown in Fig. 5. The cost band for conventional plants reflects a fuel cost range of 27 cents to 45 cents per 1,000,000 B.Th.U. at the start-up date. The curves are based on a conventional fuel cost rise of 2½ per cent per year which corresponds closely with the forecasts of the Edison Electric Institute. The nuclear fuel costs were maintained constant based on the conservative expectation that the advances from the present intensive fuel cycle development programmes and increased production will offset future inflationary effects.

The closed-cycle system discussed earlier uses both a primary and a secondary loop as shown in Fig. 6. The primary loop circulates pressurised water through the reactor and a heat exchanger. Here the heat is transferred to a secondary loop, producing steam which is piped to the turbine. The condenser and other secondary equipment are all of conventional designs. To get a clear impression of the size of this 330MW reactor, the following details are of interest. The reactor vessel itself weighs 300 tons, is 41ft high and is about 12ft in inside diameter. Its walls are 10in carbon steel with an inner cladding of 1¼in of stainless steel. The fuel is in the form of uranium oxide pellets clad in either stainless steel or Zircaloy-2. To obtain more uniform heating and better fuel economy, Westinghouse developed a novel method of loading the core in three levels of enrichment. Looking down on the top of the reactor, there are three concentric circles into which the fuel elements are loaded. In the inner circle, the fuel enrichment will be about 2·1 per cent ; in the intermediate circle, 2·6 per cent ; and in the outer circle, 2·9 per cent.

The fuel life of this reactor extends over three full-power cycles. After each cycle the central circle of fuel is removed. Then the second and third layers of fuel are moved toward the centre, and a new outer layer is added of 2·9 per cent enrichment. The uniform heat rate that will result in this way will allow the use of fewer control rods and less expensive fuel, and will provide more power from a given fuel load. After the primary loop water passes through the reactor, it flows to one of the five steam generators. The flow of water through the reactor is at the rate of 75,000,000 lb per hour. Each steam generator is 45ft high and 10ft in inside diameter. The heat exchange tubes within the generator will stand in a plate 23in thick and almost 10ft wide. No plates of these dimensions have ever been produced, but feasibility studies indicate that it can be done. In each of the steam generators, approximately 900,000 lb per hour of dry and saturated steam is produced. All five generators funnel through a common header into the secondary loop, which feeds steam to the turbine at a rate of nearly 4,500,000 lb per hour.

What is the background behind the selection of a 330MW plant? Westinghouse studied the feasibility of a closed-cycle plant at every rating from 5MW to 400MW and found that the power costs reduced sharply in the closed-cycle plant until 330MW is reached, followed by a sharp levelling in the curve. This levelling reflects an added capital expenditure needed above 330MW. At that point, the largest single-shaft, 1800 r.p.m. turbine is being used and beyond this point, parallel turbines are necessary. Furthermore, the economics of the 330MW turbine are very attractive. It is a highly efficient, 1800 r.p.m., tandem-compound turbine with both a high-pressure and a low-pressure unit. Steam enters the high-pressure unit at 650 lb per square inch, passes through this first stage and into a moisture separator, and then on to the low-pressure section. The first section is designed for double flow and the second one

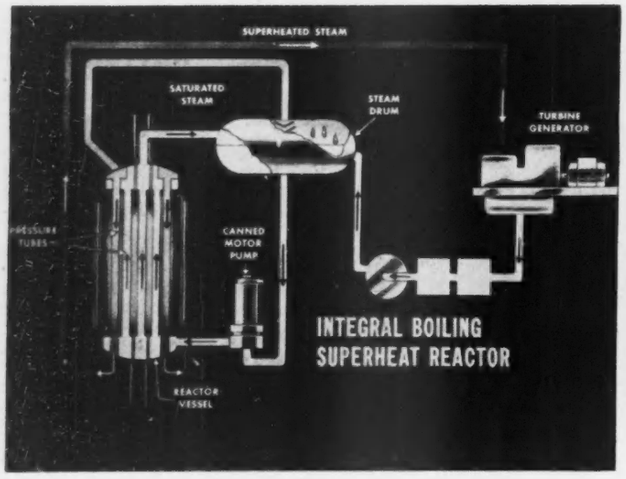


Fig. 4—General operating principle and main components of integral boiling superheat reactor plant

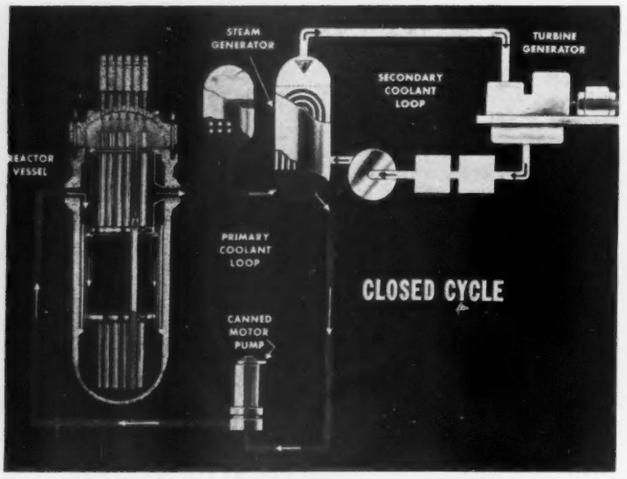


Fig. 6—General operating principle and main components of closed-cycle plant

for quadruple flow. Operating on a single shaft with 40in exhaust blades, the complete turbo-generator set will be 135ft long.

The reactor will be contained in a sphere with an overall diameter of 140ft and walls 1¼in thick. Since the technology behind closed-cycle reactors is far advanced, no serious technical problems are expected in extending the size of the reactor to match this turbine. The closed-cycle plant is anticipated to become the first all-nuclear American power plant to produce electric power on a reasonably competitive basis. The estimated figures are as follows: capital expenditure, 3·3 mills per kilowatt-hour; fuel, 3·0 mills per kilowatt-hour; operation and maintenance, 0·5 mill per kilowatt-hour. Including indirect costs of 0·5 mill per kilowatt-hour, the total cost per kilowatt-hour is 7·3 mills.

Capital Investment

In conclusion consideration will be given to the investment required to make each of the above recommendations a reality. As discussed previously, the Integral Boiling and Superheating Reactor is farther away in time than the other plants, and the first one to be built would be a 20MW prototype plant. In this case research and development cost is a large item, and estimated at 11,300,000 dollars. The capital cost of the prototype plant itself is estimated at 17,000,000 dollars. The estimates of costs for each of these plants include all probable expenditures for components and building materials. Naturally, such items as taxes, interest during construction, land, site improvements, and general administrative and overhead charges are not included, since they could not be estimated accurately without reference to a specific contract. However, they have been estimated at 0·5 mill per kilowatt-hour.

The 225MW Combination Plant can be built essentially from to-day's technical knowledge. As a result, the research and development cost is estimated at only 4,500,000 dollars. The plant itself will cost 45,000,000 dollars. The third recommended plant is the 330MW Closed-Cycle Plant. Again, because of its proven design, a relatively low research and development cost of 4,400,000 dollars is required. The plant itself will cost 68,000,000 dollars, which is a relatively low capital investment per kilowatt-hour. Deciding which of these plants fits the purposes of a specific power company is a difficult task. But the perspective can be established a little better by comparing these three plants on a mills per kilowatt-hour basis. The 20MW Prototype Integral Boiling and Superheating Plant is not designed to be competitive economically to-day because its principal product will be knowledge and experience, not power. In the long range, this will be the forerunner of a larger economical power plant. The 330MW plant also has a very promising long-range picture, but at the same time is attractive here and now. As mentioned before, the conservative power cost figure for this plant is 7·3 mills per kilowatt-hour. It is felt that for the next half-century this will, in all probability, be the most practical nuclear power plant. Thus, to-day's most economical plants, at an estimated 7·3 mills per kilowatt-hour, are the 330MW and the Combination plants. In the long range, the latter one is subject to higher power costs because of the rising price of fossil fuels. In announcing these proposed nuclear power plants to the industry, Westinghouse went as far as offering to guarantee the manufacturer's controllable costs, such as plant capital cost, plant capability and fuel burn-up. Having these guaranteed, the cost of energy to the utility is directly a function of plant load factor, individual annual charges and operation and maintenance costs—all of which the utility company can control.

Tape-Controlled Heliarc Spot Welding Machine

A NEW tape-controlled, multiple-torch Heliarc spot welding machine has been developed by the Linde Division of the Union Carbide Corporation, and is being employed by the Convair Division of the General Dynamics Corporation to produce "problem" parts for "Terrier" surface-to-air guided missiles. Production problems were encountered on some "Terrier" parts, such as the control and dorsal fins, because the parts could be welded from only one side. Since conventional resistance spot welding techniques require that both sides of a joint be accessible, it was impossible to use these methods. Heliarc spot welding, however, requires access to only one side of the joint. The welds are produced by a tungsten electric arc, shielded by inert argon gas. Since the heat of the arc melts the metals through the joints, the second side of the joint need not be accessible. Heliarc spot welding, thus, is ideal for joining parts in which two or more surfaces must be welded to a core. Because it requires access to only one side, the process is superior to resistance spot welding in three particular situations: (1) when it is impossible to reach the underside of the joint; (2) when it is necessary not to mar or depress the underside of the joint; and (3) when the bottom piece of the joint is thicker than the top piece by more than a four-to-one ratio.

Heliarc spot welding utilises a new method of positive and instantaneous arc ignition, known as Pilot-Arc starting. This starting system eliminates all high-frequency interference problems and avoids the contamination problems of retract starting. Electrode life is increased by a factor of four over high-frequency starting, and the process reliability is greatly increased. Multiple mechanised Heliarc spot welding, adaptable either to semi-automatic or fully-automatic production programming, has a wide potential in automotive, aircraft and missile applications. The machines can be equipped with enough torches to produce a virtually unlimited number of spot welds simultaneously. They are similar to programme-controlled milling machines or jig borers in that they are basic tools and can be adapted to produce a wide variety of weldments within the dimensional limits of the machines. Multiple-torch operation permits a degree of production flexibility that ensures the maximum in production capacity. Accordingly, Convair contracted with Linde to design and construct a tape-controlled programmer and welding machine that could produce up to four identical parts at one time. The machine has four torches, arranged so that four parts may be welded simultaneously. Hydraulic controls position the torches horizontally and they are raised and lowered pneumatically. Under sub-contract to Linde, two other firms supplied parts for the Convair installation. The Welding Machine Division of the Expert Tool and Die Company, of Detroit, supplied mechanical and hydraulic components, while a punched-tape programme control unit was supplied by the Farrand Controls Corporation, of New York.

The programme-controlled automatic Heliarc spot welding machine consists of a pair of flat ways mounted at right angles to one another and supported on a base. The slides are controlled by a programme control unit to position the torches on the "X" and "Y" axes. The ways are made of ductile iron castings, flame-hardened and ground. They operate against the saddle, which is soft and hand-scraped to fit. The bearing areas of the saddle are grooved for lubrication, and wipers are provided for all moving surfaces. The slides are positioned by means of hydraulic motors operating through suitable reduction gears and a ball-bearing lead screw. The lead screws are mounted in dual radial preloaded bearings. Provision is made to avoid screw compression with temperature changes. A horizontal beam, mounted on the upper slide, provides mounting surfaces for the slides used to raise and lower the welding torches. In the "Terrier" application, the geometry of the control and dorsal fins requires adjusting the surface of the workpiece so that it is normal to the electrode at all times. Therefore, a work-support platen was designed that automatically tilts the workpiece to the required position. This control function is called the "Z" axis. Welding tooling used to locate and restrain the weldment is attached to the flat surface of the platen. The platen itself is mounted on trunnion bearings so that the workpiece can be adjusted to maintain the proper angle to the electrode. A change of tooling consists of removing the tooling from the platen and replacing it with the new required nesting device. The work platen assembly is designed as a detachable unit, since it may be desirable to install different kinds of platens for future weldments.

A punched tape programme control unit preselects intelligence to the machine to establish the "X," "Y" and "Z" locations for each weld. In addition, the control selects the combination of torches to be used at each distinct step in the welding programme, as well as the desired time and current at each step. The programme control unit supplies signal information through a sequence control panel to control the sequence of operation of the machine and the welding cycle. The system contains a "Flexowriter" electric tape-punching typewriter and a tape-reading system. They are electro-mechanical, and the primary control functions emanate from relay contacts. The movement of the machine to a position is determined by two kinds of electrical signals. One signal indicates the position to which it is desired to move. The second signal indicates the actual position of the machine. This latter signal is provided by a two-phase resolver coupled to the ball-bearing lead screws through a backlash-free gear train. As the machine moves toward the desired position, the difference between the two signals, known as the error voltage, is reduced to zero when the desired point is reached. The speed of movement of the machine is directly proportional to the error voltage present.

The torches consist of two items: a special mechanised Heliarc spot welding torch and a cast copper-alloy water-cooled torch holder. A replaceable gas cup assembly is attached to the lower end of the torch holder. This cup is brought in contact with the workpiece to control accurately the spacing between the electrode and the workpiece, and to transmit sufficient clamping pressure to ensure that the parts to be welded are in intimate contact during the welding cycle. The torches are mounted on linear ball-bearing slides which are pneumatically operated by individual air cylinders. Balanced air pressures are used to provide the necessary clamping force between the gas cup of the torch and the workpiece. This ensures contact between the parts to be welded and avoids unnecessary distortion of the workpiece during welding. The cylinders operating the slides are supplied with regulated, filtered and lubricated compressed air from a manifold on the machine.

In the "Terrier" application, each torch covers a 20in by 20in area. Since these areas are adjacent, the four torches cover a 20in by 80in area. If desired, some overlap of these areas can be realised. The repetitive accuracy of the machine permits relative positioning between torches and workpiece within 0·001in cumulative error for all three planes. Welds are made on both S.A.E.1020 carbon steel and 17–7 PH stainless steel, with the pieces varying from 0·0016in to 0·0090in thickness. As originally designed, the number of spot welds and the distance between them on the control and dorsal fins were based on resistance spot welding experience. However, uniformity and shear strength tests showed that the Heliarc spot welds were considerably stronger than the resistance welds on a production basis, thus permitting a reduction in the number of welds per piece. All of the welds are shielded from atmospheric contamination by 99·995 per cent pure argon.

Personal and Business

Appointments

MR. HERMAN KAUFMANN has joined the board of directors of B. O. Morris (Holdings), Ltd.

MR. JOHN ROBINSON DAVIES has been appointed manager in Europe for Soiltest Inc., Chicago.

OPPERMAN GEARS, Ltd., has announced the appointment of Mr. A. Barton as works manager.

MR. JOHN COOKE has been appointed director-export of A.E.C. (Sales), Ltd., upon the retirement of Mr. J. M. E. Fell.

MR. H. MORLEY has been appointed a director of Samuel Fox and Co., Ltd., a subsidiary of The United Steel Companies, Ltd.

THE MINISTRY OF AVIATION has announced that Sir Frederick Brundrett has been appointed chairman of the Air Traffic Control Board.

UNION CARBIDE INTERNATIONAL COMPANY announces the appointment of Mr. E. E. Griesser as manager of the Union Carbide technical service laboratory, to be located in Geneva, Switzerland.

MR. J. A. HEPWORTH has been appointed chief engineer of the North Thames Gas Board as from January 1, 1960. He succeeds Dr. J. Burns, who, on that date, becomes deputy chairman of the board.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that Mr. T. B. Ellis has been appointed secretary, in succession to Mr. T. B. O. Kerr, who has been appointed director for finance and administration.

MR. H. V. OVERFIELD, M.I.Mun.E., M.I.C.E., has been appointed as secretary of the Institution of Municipal Engineers for an interim period, in view of the retirement of Mr. C. W. Scott-Giles on December 31.

MR. ERIC A. ROBINSON, M.I.Mech.E., has been appointed chairman of Stein Atkinson Vickers Hydraulics, Ltd., in place of Mr. H. C. J. Russell Smith, who has resigned but will remain on the board.

THE COUNCIL OF INDUSTRIAL DESIGN announces that Mr. Michael Farr is to become chief information officer on January 1, 1960. He will succeed Mr. Noel White, who becomes deputy director on the same date.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., announces that Mr. G. M. Ingram, A.M.I.E.E., has been appointed branch manager of the Manchester office, and Mr. R. Atkins has been appointed branch manager of the Sheffield office.

THE BRITISH TRANSPORT COMMISSION announces that Mr. Stanley Kennedy, chairman of the Tilling Group management board, will retire on March 31, 1960. He will be succeeded by Mr. Maurice Holmes, an executive director of the board.

THE BRITISH BROADCASTING CORPORATION announces the appointment of Mr. G. Dukes as engineer-in-charge of the Les Platons television transmitting station, Jersey, Channel Islands, in succession to the late Mr. J. J. Allen.

DR. D. W. DAVIDSON has been transferred to the central personnel executive staff at the head office of The Plessey Company, Ltd., to assist the personnel director with scientific and technical appointments throughout the company and its associates.

THE INSTITUTE OF METALS announces that the following members have been elected to fill vacancies on the Council, with effect from the annual general meeting on March 29, 1960: president, Sir Ronald Prain; vice-presidents, Dr. H. M. Finniston and Mr. H. W. Hignett.

THE GENERAL POST OFFICE announces the appointment of Mr. A. H. Mumford as engineer-in-chief in succession to Brigadier Sir Lionel H. Harris, who is retiring on January 31, 1960. Captain C. F. Booth and Mr. D. A. Barron have been appointed deputy engineers-in-chief with effect from February 1, 1960.

ENGLISH STEEL FORGE AND ENGINEERING CORPORATION, Ltd., announces the following new appointments: Mr. R. W. Brocklehurst, director, becomes general superintendent; Mr. E. Levesley, manager, becomes superintendent of the forge machine shops; Mr. R. J. H. Hunt, manager, becomes superintendent of the heavy forge.

VICKERS, Ltd., announces that Mr. A. H. Hird, chairman of Cooke, Troughton and Simms, Ltd., has found it necessary to resign from the board of that company and from his office as chairman, owing to the extent of his other duties within the Vickers Group. Mr. R. P. H. Yapp, a director of Vickers, Ltd., has been appointed a director and chairman of Cooke, Troughton and Simms, Ltd., in succession to Mr. Hird.

MR. D. A. W. MUIR has been appointed chief engineer to R. and J. Dick, Ltd., and its subsidiary companies in the United Kingdom. The following additional representatives have also been appointed at the company's British branches: Mr. William Fort, Birmingham; Mr. Thomas Cook, Leeds; Mr. Joseph Sinclair, Newcastle.

TURNER AND NEWALL, Ltd., announces that Mr. R. M. Bateman will relinquish the chairmanship and cease to be a director of Turners Asbestos Cement Company, Ltd., with effect from January 1, 1960. He will devote his time wholly to the functions of deputy chairman of Turner and Newall, Ltd. He will be succeeded as chairman of Turners Asbestos Cement Company, Ltd., by Mr. K. Neve.

ENGLISH STEEL CORPORATION, Ltd., announces that the following appointments have been made in respect of wholly-owned subsidiary companies: Mr. W. D. Pugh, to the office of chairman of English Steel Forge and Engineering Corporation, Ltd., English Steel Rolling Mills Corporation, Ltd., English Steel Castings Corporation, Ltd., English Steel Spring Corporation, Ltd., Taylor Brothers and Co., Ltd. Mr. W. E. A. Redfearn, to the office of managing director of English Steel Forge and Engineering Corporation, Ltd. Mr. R. G. H. Taylor, to the office of chairman of English Steel Export Corporation, Ltd. Mr. G. Craven, to the office of managing director of English Steel Export Corporation, Ltd.

Business Announcement

MR. OSBORN HURST is retiring from the post of chief representative of Bureau Veritas in the United Kingdom.

THE EAST SUSSEX ENGINEERING COMPANY, Ltd., has opened an office at 270, Upper Tooting Road, London, S.W.17 (telephone, Balham 3136).

NETTLE ACCESSORIES, Ltd., states that its London office and depot is now installed in new premises at 11–12, Paddington Green, London, W.2 (telephone, Ambassador 3231/2).

FRENCH RAILWAYS, Ltd., states that from December 7, it will occupy premises at 10, Haymarket, London, S.W.1 (telephone, Whitehall 3822), during the erection of its new office building at 179, Piccadilly, W.1.

ELECTRON COIL COMPANY, Ltd., Lount Works, Ashby - de - la - Zouch, Leicestershire, states that Atalanta S.R.L., via Tasso 5, Busto Arsizia, Italy, has been appointed as selling agent for "Decco" solenoids in Italy.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that its London publicity office (press section under Mr. G. A. T. Burdett) is now located at Crown House, Aldwych, London, W.C.2, Room 208 (telephone, Temple Bar 8040).

THE PLESSEY COMPANY, Ltd., announces that production of "Modac" connectors, hitherto carried out by its associate company, Modern Acoustics, Ltd., at Boreham Wood, Herts, has now been transferred to the wiring and connectors division of Plessey at Cheney Manor, Swindon.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., has completed an agreement with Vöest A.G., Linz, for exclusive co-operation between the two companies in the United Kingdom in the design, supply and erection of plant and equipment for the LD-steelmaking process.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has announced that the activities of The Metropolitan Electric Cable and Construction Company, Ltd., are being merged with those of British Insulated Callender's Cables, Ltd., and from January 1, 1960, will be transferred progressively from Chadwell Heath, Essex, to Erith Works, Kent.

LAPOINTE MACHINE COMPANY, Hudson, Mass, U.S.A., has been formed as a subsidiary of The Lapointe Machine Tool Company, to sell and service in America machine tools manufactured by Associated British Machine Tool Makers, Ltd., 17, Grosvenor Gardens, London, S.W.1. The five member companies of Associated British Machine Tool Makers, Ltd., are The Butler Machine Tool Company, Ltd., The Churchill Machine Tool Company, Ltd., John Lang and Sons, Ltd., J. Parkinson and Son (Shipley), Ltd., and H. W. Ward and Co., Ltd.

Contracts

HOLLAND & HANNEN AND CUBITTS (NORTH WEST), Ltd., has been awarded a contract valued at £325,000 for a new plastics factory at Speke, Liverpool, for the Metal Box Company, Ltd. The factory will measure 270ft by 250ft and there will be a two-storey office block, all due for completion in the autumn of 1960.

BRISTOL AEROPLANE COMPANY, Ltd., reports that the Bristol-Ferranti "Thor" semi-active anti-aircraft missile, with two Bristol-Siddeley "Thor" ramjets, is to be ordered for the defence of Australia.

BRITISH OXYGEN (HONG KONG), Ltd., has stated that its production of oxygen will be doubled in 1960. A plant is to be supplied from the United Kingdom by British Oxygen Engineering, Ltd., Edmonton. The new plant will be capable of producing more than the existing four plants. Erection is to begin in the early part of 1960 and it is anticipated that the plant will be in full production by the second half of next year.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received from the Central Electricity Generating Board an order worth about £383,000 for two 310MVA generator transformers, 18/295kV each, with a shipping weight of 170 tons, to be installed in the new 1100MW power station at Thorpe Marsh, on the north bank of the River Don near Doncaster. They will be equipped with on-load high-speed tap-changers and will be cooled by pumped oil circulation through water coolers. The transformers will be manufactured and fully tested at the company's Stafford works; the tests will include a full-load loss heat run.

DORMAN LONG (BRIDGE AND ENGINEERING), Ltd. and GAMMON PAKISTAN, Ltd., working in association, have been awarded a contract by the Government of Pakistan for the construction of a bridge at Sukkur, West Pakistan, over the Rohri Channel of the River Indus. The structure is a spandrel-braced arch with a span of 807ft on massive concrete abutments. The bridge will carry a single track railway, which will be set in a concrete deck for the use of road vehicles. The total weight of steelwork is approximately 3300 tons. The value of the contract is £1,155,000 and has been secured in face of German, Austrian and American competition. The consulting engineer is Mr. D. B. Steinman, of New York. The bridge is intended to replace the famous Lansdowne Bridge.

ROBERT WATSON AND CO. (CONSTRUCTIONAL ENGINEERS), Ltd., of Bolton, has been awarded the contract for the structural steelwork for the South-West Face, Passenger Building at London Airport Central involving over 1800 tons of steelwork. The consulting engineers are Sir William Halcrow and Partners. Robert Watson and Co. has also secured a contract from the main contractors, A. Monk and Co., Ltd., of Warrington, for the steelwork to the Gathurst Viaduct, involving 2150 tons. The viaduct, supervised by Mr. J. Drake, the Lancashire C.C. surveyor and bridgemaster, is 800ft long and 108ft wide and will carry the North-South motorway over an occupation road, the River Douglas, the Leeds–Liverpool Canal and the Wigan–Southport Line railway. The two contracts are worth over £400,000.

Miscellanea

ALUMINIUM JUBILEE.—We have been informed that in the article "Golden Jubilee of Aluminium Production at Dolgarrog," which appeared in our issue of November 20, the conveyor shown in the lower illustration was supplied by Herbert Morris, Ltd.

SUSPENSION DEVICE FOR PIPES AND CABLES.—A suspension device for power cables, tubes and small pipelines which is in the form of a self-tightening plaited nylon sleeve has been introduced by the Worcester Fabrications Company, of Worcester. This sleeve is slipped over the pipe or cable and when suspended from the end its meshes close on the line to support weights up to 650 lb. Various end suspension means are provided, including flanges for screwed couplings, nylon tapes, &c., and it is stated the device holds firmly on smooth-surfaced pipes or tubes. When the weight is released the device can easily be slipped off the line it supports. The sleeves are made in a number of sizes to accommodate lines from 0·29in to 1·7in diameter.

DISTRIBUTION FUSEBOARDS.—A new range of distribution fuseboards, known as "Kantark-Excel," is announced by the Midland Electric Manufacturing Company, Ltd., Reddings Lane, Tyseley, Birmingham, 11. They have been designed to incorporate in a standardised form in the four different categories (single-pole and neutral, double-pole, triple-pole and triple-pole and neutral) a large number of characteristics which are recognised as desirable for commercial and industrial applications. Cases are of heavy gauge rustproofed steel with stove grey enamel finish. Resilient foam rubber gaskets are fitted to all covers, which are detachable to facilitate wiring. The depth of the cases provides ample wiring space at the back of the fuse-banks. Rewirable or h.r.c. pattern fuses are accommodated for 15A to 100A, 500V.

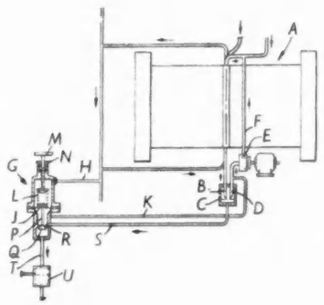
British Patent Specifications

When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

ELECTRICAL ENGINEERING

822,086. May 3, 1957.—ELECTRICAL BATTERIES, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Francis Thomas Bacon.*)

This invention is particularly concerned with the operating details of a complete battery of hydrogen-oxygen fuel cells. During the operation of such a battery the hydrogen and oxygen consumed are converted into water which tends to accumulate in the vicinity of the hydrogen electrodes. According to the present invention, a fuel cell of the hydrogen-oxygen type having porous electrodes is provided with a hydrogen circulation system which includes a condenser for the steam carried by the circulating hydrogen and the condensate from this condenser is periodically released by means of a valve controlled by the differential pressure between the electrolyte and the hydrogen necessary for balancing the capillary attraction in the pores of the electrodes. Referring to the drawing, hydrogen emerges at the bottom of the battery *A* by way of a pipe *B* which constitutes the inlet pipe to a condenser in the form of a small pot *C*. The outlet from the pot is a pipe *D* leading to the pump *E* which completes the circuit by way of the pipe *F*. The battery is designed to work at relatively high temperatures, for example, of the order of 200 deg. Cent., and the circulating hydrogen carries with it steam which is condensed in the pot *C*. The pipes *B* and *D* extend downwardly within the pot and have tapered ends to prevent the formation of drops. As the level of condensate in the pot rises, so the ends of the pipes are obstructed and since only a relatively small pressure is obtained from the pump, the circulation of hydrogen stops. Stoppage of the hydrogen circulation causes the differential pressure between the electrolyte and the hydrogen to drop and this effect is used for the control of the valve

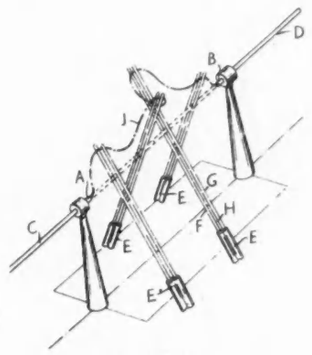


No. 822,086

G. The electrolyte pressure is fed to the valve by way of a pipe *H* so as to act on the upper side of a diaphragm *J*. The lower side of the diaphragm is acted on by the hydrogen pressure connected by way of a pipe *K* leading off the pipe *D*, just above the pot *C*. As a consequence, the differential pressure acts upwardly on the diaphragm, where it is balanced by a light spring *L*, the compression of which is adjusted by means of a screw *M* passing through a gland *N*. The diaphragm carries a stem *P* provided at its lower end with a valve member *Q* co-operating with a seating *R*. As the differential pressure drops with the stoppage of condensation, the spring opens the valve and allows condensate to escape from the pot *C* by way of a pipe *S* leading to the space below the diaphragm *J*. The condensate flows away to atmosphere through a pipe *T* which includes a steam pipe trap, shown diagrammatically as *U*. This avoids the relatively small valve *G* having to operate against the effects of a large pressure.—*October* 21, 1959.

822,019. December 30, 1955.—HIGH-VOLTAGE CIRCUIT-BREAKERS, A. Reyrolle and Co., Ltd., Hebburn, County Durham. (*Inventors: John Christie and Austin Frederick Brabant Young.*)

The purpose of the present invention is to provide a means for extinguishing the arc on separation of circuit-breaker contacts by rapidly lengthening it and cooling it in free air to an extent at which it ceases to be electrically stable, without using an arc control device. In the embodiment illustrated, a high-voltage electric circuit-breaker has circuit-breaking contacts *A*, *B*, which are separated by rapidly withdrawing the rods *C* and *D* axially from one another. The contacts are not enclosed in any form of arc control device, and their line of separation is a horizontal straight line. Mounted below the line of separation of the contacts are a number of earthed nozzles *E*, each connected to a source of compressed air and arranged to direct a high-velocity jet of air transversely at the arc on the operation of the circuit-breaker. Each nozzle is provided with twin orifices disposed close to one another side by side and arranged to direct at the arc an air jet consisting of two approximately parallel high-velocity streams



No. 822,019

of air *F* and *G* side by side with a central stream *H* of lower air velocity between the two high-velocity streams. Alternatively, the nozzles might each have a single orifice of what may be termed "dumbell" or "hour-glass" section, comprising two wide portions joined by a narrower neck portion. The nozzles are successively offset on alternate sides of the vertical projection of the line of separation of the contacts, and each is orientated so that the axis of its jet intersects the line of separation of the contacts at right angles and the two high-velocity air streams pass one on either side of the line of separation. Thus, the nozzles are alternately inclined in opposite directions to the vertical and their inclined jets of air impinge on the arc from different directions. Furthermore, the jets of air are arranged to be already established on the operation of the circuit-breaker before the arc is drawn through them. Thus, the effect of the impingement of the jets of air on the arc is to elongate the arc by forcing elements of it simultaneously in different transverse directions, distorting it to a sinuous, serpentine form as indicated at *J* and simultaneously cooling it, until it is eventually extinguished. The circuit-breaking contacts are connected in parallel with a pair of heavier contacts (not illustrated) which normally carry the load when the circuit-breaker is closed, and which are opened first, leaving the circuit to be interrupted by the circuit-breaking contacts. Thus, the latter, which do not have to carry a continuous load, may be of lighter construction than otherwise and can therefore be separated more rapidly on account of their reduced inertia.—*October* 21, 1959.

METALLURGY

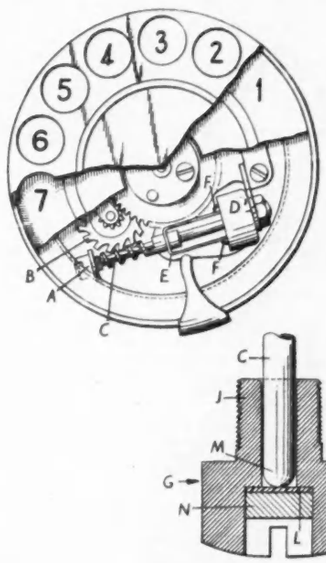
822,789. December 2, 1957.—SPHEROIDAL GRAPHITE CAST IRON, International Harvester Company, 180, North Michigan Avenue, Chicago, 1, Illinois, United States of America.

This invention relates to a new ferrous alloy which may be made from any base irons that are hypereutectic in relation to carbon content and can be readily made from extremely low strength high-carbon pig iron directly from the blast furnace. More particularly it relates to the production of high mechanical strength nodular iron in the as-cast condition directly from molten pig iron as tapped from a blast furnace or from molten commercial normal grey iron of hypereutectic composition. The iron to which the nodulising agent is added must be hypereutectic in relation to carbon content, and in the as-cast condition should contain not more than 0·03 per cent of sulphur. A preferred nodulising agent according to the invention is metallic lanthanum or metallic neodymium or both. The metals may be added as such or as alloys in which cerium occurs, if at all, as an impurity. The amount of nodulising agent added to the iron must be sufficient to ensure that the iron in the as-cast state contains not less than 0·02 per cent of lanthanum or of lanthanum plus neodymium. As the amount is increased the proportion of nodular graphite to flake graphite rapidly increases, the optimum being reached at 0·04 per cent of residual nodulising agent. Beyond that point lanthanum appears to act as a carbide stabiliser and the castings become hard without substantial change in tensile strength. The effective range is 0·02 to 0·06 per cent of lanthanum or lanthanum plus neodymium in the cast iron, 0·04 per cent being preferred. Amounts in excess of 0·04 per cent should be used only when hard, wear-resistant castings are desired. The molten iron may, if desired, be inoculated with ferrosilicon or other graphitising agent before pouring, whereby more free carbon becomes available for nodule-formation.—*October* 28, 1959.

TELECOMMUNICATIONS

822,300. July 26, 1956.—TELEPHONE DIALS, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Charles Clarke Puckette, Jnr., of The General Electric Company, Ltd., Telephone Works, Coventry.

This invention is particularly concerned with telephone dials in which thrust bearings are employed for supporting the spindles of the dial governor assemblies. Since it is necessary that a telephone dial shall be capable of providing trouble-free service over long periods, it is essential that the wear at the end of the governor spindle and at the surface on the governor pivot bearing on which the spindle turns shall be kept to a minimum. The upper drawing shows a plan view of a telephone dial partly cut away to show the governor assembly. Apart from the thrust bearing *A* of the governor assembly, the dial is of the kind employed at the present time by the British Post Office. A worm wheel *B* meshes with a worm formed on the metal spindle *C* of the governor assembly. This includes a governor cup *D* which is fixed to a bracket supported by the case. This cup provides the support for one end of the spindle. The other end of the spindle is supported by the thrust bearing *A* which is in accordance with the present invention. Two wings *E* are attached to the governor spindle, each of these having a small weight *F* at its free end. The wings are flexible so that when the spindle is rotated the weights move outwards from the spindle under the influence of centrifugal force and rub over the inner surface of the governor cup *D*. Referring to the lower drawing, the body portion *G* of the bearing *A* is usually of



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metal, such as brass, but this is not essential. The head *H* of the body portion is provided with a circular aperture having a substantially flat base. A circular hole of smaller diameter than the aperture extends through the shank *J* into the aperture. The end *M* of the spindle is hemispherical but alternatively it may comprise a portion of a sphere having a somewhat larger diameter than the spindle. A disc *L* of polytetrafluorethylene (P.T.F.E.) is positioned in the base of the aperture. This provides the surface of the bearing *A* on which the end *M* of the spindle turns. As the disc is extremely thin, it is backed by a plug *N* of metal or of a suitable synthetic material. In the initial stages of use, the thrust applied along the axis of the spindle results in a substantial pressure on the contacted surface of the P.T.F.E. disc. This pressure causes the end *M* of the spindle to form a small indentation in the relatively soft P.T.F.E. Thus, the area of the contacted surface of that disc is increased so that the pressure caused by the thrust is decreased. Owing to the very low coefficient of friction of P.T.F.E. this increase in the area of the contacting surfaces is of negligible effect.—*October* 21, 1959.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Dec. 4.—LIVERPOOL AND DISTRICT BRANCH: Industrial Development Centre, Paradise Street, Liverpool, 1, "Fire Protection." J. R. Moyle, 7.30 p.m.

Mon., Dec. 7.—BOLTON BRANCH: Railway Hotel, Trinity Street, Bolton, "Medium Voltage Distribution Gear: Current Practice and Future Trends." W. Harding, 7.45 p.m. ★ BOURNEMOUTH AND DISTRICT BRANCH: Grand Hotel, Firvale Road, Bournemouth, Films Evening, 8 p.m. ★ ESSEX BRANCH: Angel Hotel, Ilford, "Mineral Insulated Cables—Latest Applications." H. W. M. Parker, 8 p.m. ★ LEEDS BRANCH: Great Northern Hotel, Leeds, "Refrigeration," 7.30 p.m. ★ SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield "Earth Impedance and Earth Leakage Testing." P. Laughton, 7.30 p.m.

Tues., Dec. 8.—CHESTER AND DISTRICT BRANCH: Westminster Hotel, Chester, "The Application of Electricity in Oil Refining." S. York, 7.45 p.m. ★ GLASGOW BRANCH: Kenilworth Hotel, Queen's Street, Glasgow, C.1, Film, "Electrical Shop Window of 1959," 8 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH: M.L.N.S. Office, Lake Road, Portsmouth, "Electric Underfloor Heating." R. Siverns, 7.30 p.m. ★ SOUTH-EAST LONDON BRANCH: Eltham Green School, Queenscroft Road, Eltham, London, S.E.9, "The Work of the A.S.E.E.," E. A. Bromfield, and Film, "Electrical Shop Window of 1959," 7.45 p.m. ★ YORK BRANCH: Georgian House, Blossom Street, York, "Modern Electric Motor Specification," J. Spence, 7.30 p.m.

Wed., Dec. 9.—BIRMINGHAM BRANCH: Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, Film Show, 7.30 p.m.

Thurs., Dec. 10.—BRADFORD AND DISTRICT BRANCH: Midland Hotel, Bradford, "Relays and Auto-Control in Industry." W. L. Stern, 7.30 p.m. ★ SOUTH WEST LONDON BRANCH: Prince of Wales Hotel, London, S.W.19, "Modern Fire-Fighting Electrical Hazards," 7.45 p.m.

Fri., Dec. 11.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Recording Instruments," J. Campaigne and P. Death, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Dec. 8.—WEST MIDLANDS SECTION: Matthew Boulton Technical College, Suffolk Street, Birmingham, "The Development of High Frequency Tape Recording." P. J. Guy, 7.15 p.m.

Wed., Dec. 9.—NORTH EASTERN SECTION: Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Micro Miniaturization," H. G. Manfield, 6 p.m.

Thurs., Dec. 10.—NORTH WESTERN SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, "Learning Machines." P. Huggins, 6.30 p.m. ★ LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "The Simulation of Nuclear Reactors and Power Plants," W. J. G. Cox and J. Dowsing, 6.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Dec. 9.—NORTHERN REGION: Great Northern Hotel, Leeds, Discussion on "The Clean Air Act," 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Dec. 7.—LEEDS CENTRE: British Lighting Council, 24, Aire Street, Leeds, 1, "The Next Fifty Years of Lighting Development." R. T. O. Freeth, 6.15 p.m.

Tues., Dec. 8.—LONDON CENTRE: Federation of British Industries, Tothill Street, London, S.W.1, "Lighting of Drawing Offices." J. B. Collins and F. G. Langdon, 6 p.m.

Thurs., Dec. 10.—MANCHESTER CENTRE: Demonstration Theatre, Town Hall Extension, Manchester, "Road Surface Illuminants in the Practice of Public Lighting." J. B. de Boer, 6 p.m. ★ SWANSEA GROUP: Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, "Lighting and Architecture." J. W. Waldram, 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Dec. 7.—STUDENT LECTURE: Memorial Building, 76, Mark Lane, London, E.C.3, "The Closed Feed System," T. O. Leith, 6.30 p.m.

INSTITUTE OF METAL FINISHING

Wed., Dec. 9.—ORGANIC FINISHING GROUP: British Institute of Management, 80, Fetter Lane, London, E.C.4, "Air Drying Paint Systems," F. Dunkley and D. H. Grover, 6.30 p.m.

INSTITUTE OF PETROLEUM

To-day, Dec. 4.—Shell-Mex House, Strand, London, W.C.2, Film Evening, 6 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Dec. 7.—EAST REGIONAL CENTRE: Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "Taking Stock on Maintenance." P. H. Wyke Smith, 7.30 p.m. ★ WEST REGIONAL CENTRE: Liverpool Architectural Society's Rooms, Bluecoat Chambers, School Lane, Liverpool, 1, "The Use of Plastics in Road Transport." J. Langford-Allen, 7.30 p.m.

Wed., Dec. 9.—SOUTHERN CENTRE: The Palmeira Hotel, Hove, "The Commer T.S.3 2-Stroke Diesel Engine," E. W. Coy, 7.30 p.m.

Thurs., Dec. 10.—SOUTH WESTERN GROUP: Rougemont Hotel, Exeter, "The Work of the Motor Industry Research Association." J. G. Giles, 7.30 p.m. ★ WESTERN CENTRE: Royal Hotel, Bristol, "Turbocharging Diesel-Engined Road Vehicles." K. B. Hopfinger and R. Tytler, 6.30 p.m.

Fri., Dec. 11.—SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, "Glass Fibre Reinforced Plastics," G. O. Gurney, 7.15 p.m.

INSTITUTE OF WELDING

To-day, Dec. 4.—54, Princes Gate, London, S.W.7, Conversazione, "I.I.W. Work in Hand," 4 p.m.

Tues., Dec. 8.—SLOUGH SECTION: Lecture Hall, Community Centre, Farnham Road, Slough, "Low Temperature Welding and Brazing." 7.30 p.m.

Wed., Dec. 9.—SOUTH LONDON BRANCH: 54, Princes Gate, London, S.W.7, "Plant Characteristics for Welding." J. C. Needham, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Wed., Dec. 9.—LONDON CENTRE: Cromwell Hall, Earls Court, London, S.W.5, "Developments in Tractor Transmission Systems and their Lubrication." E. S. Bates, 3 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Dec. 8.—NORTH WESTERN BRANCH: Chemical Engineering Lecture Theatre, Manchester College of Science and Technology, Jackson Street, Manchester, "Chemical Engineering Problems in Hydrogen Peroxide Production," W. R. Holmes, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., Dec. 10.—TRAFFIC ENGINEERING STUDY GROUP: Great George Street, London, S.W.1, Discussion on "Standards of Design of Rural Roads," introduced by J. T. Duff, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Dec. 4.—MEDICAL ELECTRONICS DISCUSSION GROUP: Savoy Place, London, W.C.2, Discussion on "Nuclear Magnetic Resonance," opened by N. Sheppard and R. E. Richards, 6 p.m. ★ SOUTH MIDLAND CENTRE: Midland Institute, Birmingham, Joint Meeting with the Midland Branches of the Institution of Civil Engineers and the Institution of Mechanical Engineers, "The Jodrell Bank Radio Telescope." H. C. Husband, 6 p.m.

Mon., Dec. 7.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Frequency Patterns for Multiple-Radio-Channel Routes." B. B. Jacobsen, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE: Technical College, Cambridge, "Rockets and Satellites." R. L. F. Boyd, 6.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, "The Deltic Locomotive," C. M. Cock, 6.30 p.m. ★ NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP: Rutherford College of Technology, Newcastle upon Tyne, 1, "Dielectric Materials—Trends and Prospects," C. G. Garton, 6.15 p.m. ★ SOUTH MIDLAND CENTRE: College of Technology, Birmingham, Joint Meeting with the Electronics and Measurement and Supply and Utilization Groups, "Some Industrial Applications of Electro Heat." E. May, 6 p.m. ★ WESTERN CENTRE: Technical College, Gloucester, "The Influence of Consumers' Load/Consumpt on Characteristics on Metering Practice," L. B. S. Golds, 6 p.m. ★ S. MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, "Some Industrial Applications of Electro Heat." E. May, 6 p.m.

Tues., Dec. 8.—CAMBRIDGE ELECTRONICS AND COMMUNICATIONS GROUP: Cavendish Laboratory, Free School Lane, Cambridge, "The Reliability of Components." G. W. A. Dummer, 8 p.m.

Wed., Dec. 9.—SUPPLY SECTION: Savoy Place, London, W.C.2, "Field Suppression of Turbo-Alternators." J. R. Hill, A. Hunt, W. J. Joyce and D. H. Tompsett, 5.30 p.m. ★ N.W. ELECTRONICS AND COMMUNICATIONS GROUP: Engineers' Club, Albert Square, Manchester, "New Amplifying Techniques." C. W. Oatley, 6.15 p.m. ★ N. LANCASHIRE SUB-CENTRE: N.W. Electricity Board Demonstration Theatre, Friargate, Preston, "Subscriber Trunk Dialling." D. A. Barron, 7.15 p.m.

Thurs., Dec. 10.—UTILISATION SECTION: Savoy Place, London, W.C.2, "The Characteristics and Protection of Semi-Conductor Rectifiers." D. B. Corbyn, 5.30 p.m. ★ N. MIDLAND CENTRE: Yorkshire Electricity Board Offices, Ferensway, Hull, Chairman's Address, G. W. Carter, 6.30 p.m. ★ N. SCOTLAND SUB-CENTRE: Queen's College, Dundee, "Automatic Digital Recording of Experimental Values." W. H. P. Leslie, 7 p.m.

Fri., Dec. 11.—E. MIDLAND CENTRE: College of Technology, Leicester, "Electrical Floor Warming." J. W. Moule and W. M. Stevenson 7 p.m. ★ N. SCOTLAND SUB-CENTRE: Robert Gordon Technical College, Aberdeen, "Automatic Digital Recording of Experimental Values." W. H. P. Leslie, 7.30 p.m. ★ N. STAFFORDSHIRE SUB-CENTRE: Technical College, Stoke-on-Trent, "Discrimination Between H.R.C. Fuses." E. Jacks, 7 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 15.—39, Elmbank Crescent, Glasgow, "Refrigerated Ships." E. Russel Roberts, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Fri., Dec. 11.—Park Lane Hotel, Piccadilly, London, W.1, Annual General Meeting, 11.45 a.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 4.—MIDLAND BRANCH: Midland Institute, Birmingham, "Jodrell Bank Radiotelescope." H. C. Husband, Film, "The Inquiring Giant." ★ E. MIDLANDS GRADUATES' SECTION: Visit to Stanton Ironworks Company, Ltd., Near Nottingham, 7.15 p.m.

Mon., Dec. 7.—Rolls-Royce Welfare Hall, Derby, "Mechanical Design Aspects of the 'Comet' Engine," F. R. Morley, 6.15 p.m.

Tues., Dec. 8.—AUTOMOBILE DIVISION ORDINARY MEETING IN CONJUNCTION WITH THE INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Some Investigations into Cold-Starting Phenomena in High-Speed Diesel Engines." A. E. W. Austen and W. T. Lyn, 6 p.m. ★ S. WALES BRANCH: Kingsway Demonstration Theatre of the S. Wales Electricity Board, Swansea, "Application of Pneumatic Equipment to Centralised Control of Compressors." E. N. Martin and T. W. Wilkinson, 6 p.m.

Wed., Dec. 9.—ORDINARY MEETING IN CONJUNCTION WITH THE STEAM GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Design and Construction of Power Station Feed Heaters." J. V. Bigg, "Flash Evaporators for the Distillation of Sea Water." A. Frankel, 6 p.m. ★ N.E. BRANCH: Cleveland Scientific Institute, Corporation Road, Middlesbrough, "The Effect of Nuclear Radiation on Engineering Materials." A. H. Cottrell, 6.15 p.m. ★ EASTERN GRADUATES' SECTION: Visit to Thermo Plastics, Ltd., Dunstable, 2.30 p.m. ★ SOUTHERN SECTION: Technical College, Reading, "The Computer as an Aid to Mechanical Engineers." Mr. Fossey, 7.30 p.m.

Thurs., Dec. 10.—INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Practical Training of Engineers," 6 p.m. ★ N.E. BRANCH: Stephenson Building, Claremont Road, Newcastle upon Tyne, "The Effect of Nuclear Radiation on Engineering Materials." A. H. Cottrell, 6 p.m. ★ WESTERN BRANCH: Engineering Laboratories, The University, Bristol, "Materials in the Service of Mechanical Engineers." R. J. Brown, 6.30 p.m. ★ EASTERN GRADUATES' SECTION: Visit to Tollemache's Brewery, Ltd., Ipswich, 7.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Dec. 8.—BIRMINGHAM BRANCH: Hotel Leofric, Coventry, "The Safe Use of Electricity in Factories." G. L. Leighton, 7.30 p.m. ★ LEICESTER BRANCH: Grand Hotel, Leicester, "Different Aspects of Lubrication." R. Spray, 7.30 p.m. ★ MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Generation of Electrical Power from Nuclear Sources." W. G. Busbridge, 7.15 p.m.

Wed., Dec. 9.—DUNDEE BRANCH: Taypark Hotel, West Ferry, Dundee, "Construction of Modern Factories with reference to Buildings at the Dundee Industrial Estate." J. Watson Ritchie, 7.30 p.m. ★ E. MIDLANDS BRANCH: County Hotel, Theatre Square, Nottingham, "Education and Technology in Russia." I. G. Slater, 7 p.m. ★ WESTERN BRANCH: Grand Hotel, Broad Street, Bristol, "Hydraulics." E. J. Pegler, 7.15 p.m.

Thurs., Dec. 10.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Automatic Controls for Coal Fired Shell Type Boilers." P. J. Turner, 7.15 p.m. ★ MERSEYSIDE AND NORTH WALES BRANCH: "The Blossoms," Chester, "Electrical Regulations." D. A. Picken, 7.15 p.m. ★ NORTH EAST BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Hydraulics," F. H. Towler, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., Dec. 8.—DONCASTER SECTION: Technical College, Doncaster, Address by the President, G. R. Pryor, 7 p.m. ★ HALIFAX AND HUDDERSFIELD SECTION: Percival Whitley College of Further Education, Francis Street, Halifax, "Epoxy Resin Tooling." E. M. White, 7.30 p.m. ★ BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Films, "Conquest of the Atom," and "The Cotton Industry," 7 p.m. ★ LONDON GRADUATE SECTION: 10, Chesterfield Street, Mayfair, London, W.1, "The 'Comet' Fatigue Tests," R. H. T. Harper, 7.15 p.m.

Wed., Dec. 9.—LIVERPOOL SECTION: Central Libraries, William Brown Street, Liverpool, "The Development of the Sewing Machine," 7.30 p.m. ★ LUTON GRADUATE SECTION: Lecture Theatre, College of Technology, Luton, "Development of Very Large 3 Co-Ordinate Measuring Machines with Numerical Control," W. H. Jaye, 7.30 p.m.

Thurs., Dec. 10.—COVENTRY GRADUATE SECTION: Renold Chains, Ltd., Coventry Chain Works, Coventry, Works Visit and "Production of Precision Transmission Chains," 7.15 p.m. ★ WOLVERHAMPTON GRADUATE SECTION: Works visit to Quasi-Arc, Ltd., Bilston, Staffs, 2.30 p.m. ★ NORTHERN IRELAND SECTION: Kensington Hotel, Belfast, "Extraction and Fabrication of Aluminium," D. H. Abel, 7.30 p.m. ★ 1959 SIR ALFRED HERBERT PAPER: Royal Institution, Albemarle Street, London, W.1, "Production Engineering Developments in Russia," D. F. Galloway, 6.30 p.m.

Mon., Dec. 14.—LEEDS SECTION: Hotel Metropole, King Street, Leeds, 1, "Materials Purchase as an Aid to Production," D. H. Brandon, 7 p.m. ★ SHEFFIELD SECTION: Grand Hotel, Sheffield, "Fabrication of Heavy Steel Components." W. Plews, 7.15 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Dec. 7.—N.E. SECTION: Eldon Grill, Grey Street, Newcastle, "Protection of Chemical Plant," L. Crompton, 7 p.m.

Tues., Dec. 8.—LONDON SECTION: Royal Society of Tropical Medicine and Hygiene, Manson House, 26, Portland Place, London, W.1, Discussion on "Natural Rubber *v.* S.B.R.," 7 p.m.

Wed., Dec. 9.—SOUTHERN SECTION: Polygon Hotel, Southampton, "Some Aspects of the Compounding of Styrene-Butadiene Synthetic Rubbers," R. B. Moore, 7.30 p.m. ★ WEST OF ENGLAND SECTION: Melksham House, Melksham, "Recent Developments in Soviet Rubber Science and Industry," R. J. Moseley, 7.45 p.m.

Fri., Dec. 11.—LEICESTER SECTION: Bell Hotel, Leicester, "The Utilisation of Man-Made Fibres in the Rubber Industry." G. A. Pittman, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Mon., Dec. 7.—LANCASHIRE AND CHESHIRE BRANCH: College of Science and Technology, Manchester, "Timber Shell Construction," H. Tottenham, 6.30 p.m.

Wed., Dec. 9.—YORKSHIRE BRANCH: Metropole Hotel, Leeds, "The Structural Engineering Aspect of the Development of Gatwick Airport," F. S. Snow, 6.30 p.m.

Thurs., Dec. 10.—LONDON BRANCH: 11, Upper Belgrave Street, London, S.W.1, "Multi-Storey Car Parks," E. N. Underwood, 6 p.m.

Fri., Dec. 11.—WESTERN COUNTIES BRANCH: University Engineering Laboratories, Bristol, "Welded Tubular Structures." G. B. Godfrey, 6 p.m.

INSTITUTION OF WATER ENGINEERS

To-day, Dec. 4.—Institution of Civil Engineers, Great George Street, London, S.W.1, Winter General Meeting, "The Formation and Planning of the Medway Water Board," A. A. Chapman: "Water Supply in Ceylon," C. Rasiah and H. C. Husband, 10 a.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 4.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, "Nickel Matters," "The Problem of Creep in Metals," and "Spheroidal Graphite Cast Iron," 7 p.m.

Fri., Dec. 11.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Induction of President, J. M. Kay, and Presentation of Awards by W. M. Larke; "The Engineer's Role in Nuclear Power." 7.30 p.m. ★ NORTH WESTERN SECTION: Engineers' Club, Albert Square, Manchester, "Fitting an Escalator in a Ship." D. H. Clark, 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Dec. 11.—Engineers' Club, Albert Square, Manchester, 2, "Recent Developments in Shaft Sinking Techniques," W. R. Spendlove, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Dec. 11.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "Ship Model Size and Tank Boundary Correction," A. Emerson, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Dec. 8.—Library, 4, Hamilton Place, London, W.1, "Some Practical Aspects of Compressor Blade Vibration," E. K. Armstrong and R. E. Stevenson, 7 p.m.

Fri., Dec. 11.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Symposium on "Flight Safety," 10 a.m.

★ AGRICULTURAL AVIATION GROUP: Library, 4, Hamilton Place, London, W.1, "Aerial Operations Planning in the United Kingdom: Results and Difficulties," P. King, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Sat., Dec. 5.—MINING SURVEYORS' GENERAL MEETING: Institute of Advanced Architectural Studies, Micklegate, York, "Land Drainage and the 1957 Subsidence Act," S. G. Lee, 10.30 a.m.

Mon., Dec. 7.—ORDINARY GENERAL MEETING: 12, Great George Street, London, S.W.1, "The Replanning of Rotterdam," J. T. Smits, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., Dec. 9.—John Adam Street, Adelphi, London, W.C.2, "Modern Trends in Industrial Design," Sir Gordon Russell, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Tues., Dec. 8.—MERSEYSIDE GROUP: Royal Institution, Colquitt Street, Liverpool, "Evolutionary Operation in Practice," G. A. Coutie, 7 p.m.

Fri., Dec. 11.—GENERAL APPLICATIONS SECTION: Royal Institute of Public Health and Hygiene, 28, Portland Place, London, W.1, "Pitfalls in the Collection of Agricultural Statistics," H. Palca, 6.15 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Dec. 10.—Visit to the Velindre Works of the Steel Company of Wales, Ltd., 10.15 a.m.; Institute Buildings, Park Place, Cardiff, "The Tinplate Industry with Special Reference to the Cold Reduction Tinplate Plant of Trostre and Velindre," J. S. Gazard, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Dec. 9.—LONDON BRANCH: Hope House, 45, Great Peter Street, Westminster, London, S.W.1, "Radar and Telecommunications Research and Development," Elizabeth Laverick, 7 p.m.

Advanced Engineering Courses

"Predetermined Motion-Time Systems.—II. Work Factor." THE UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Birmingham, 15. Residential executive course, from 9.30 a.m., Monday, January 11, until Friday, January 29, 1960. **Fee 105 guineas.**

Linear and Non-Linear Servo Control Systems. SOUTH EAST LONDON TECHNICAL COLLEGE, Lewisham Way, S.E.1. A short course of ten lectures intended to give a brief but comprehensive introduction to the principles of control engineering. Wednesday evenings, 7 to 9 p.m., commencing January 20, 1960. **Fee £1.**

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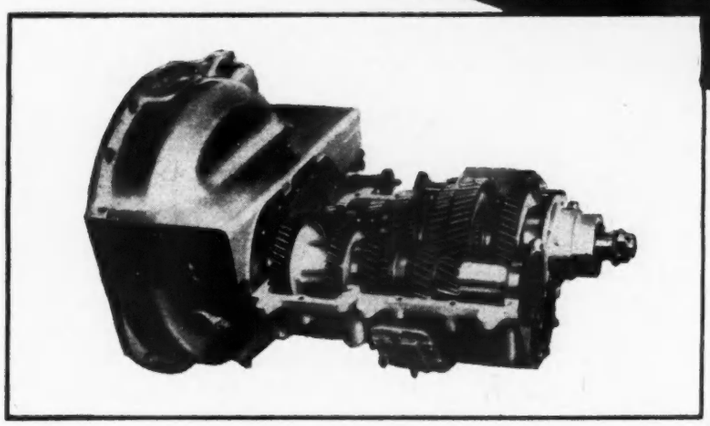

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1½ in. dia.	Oil quenched 780°C.	72·0	19	69
2⅛ in. dia.	Oil quenched 860°C. Oil quenched 780°C.	62·7	19	67
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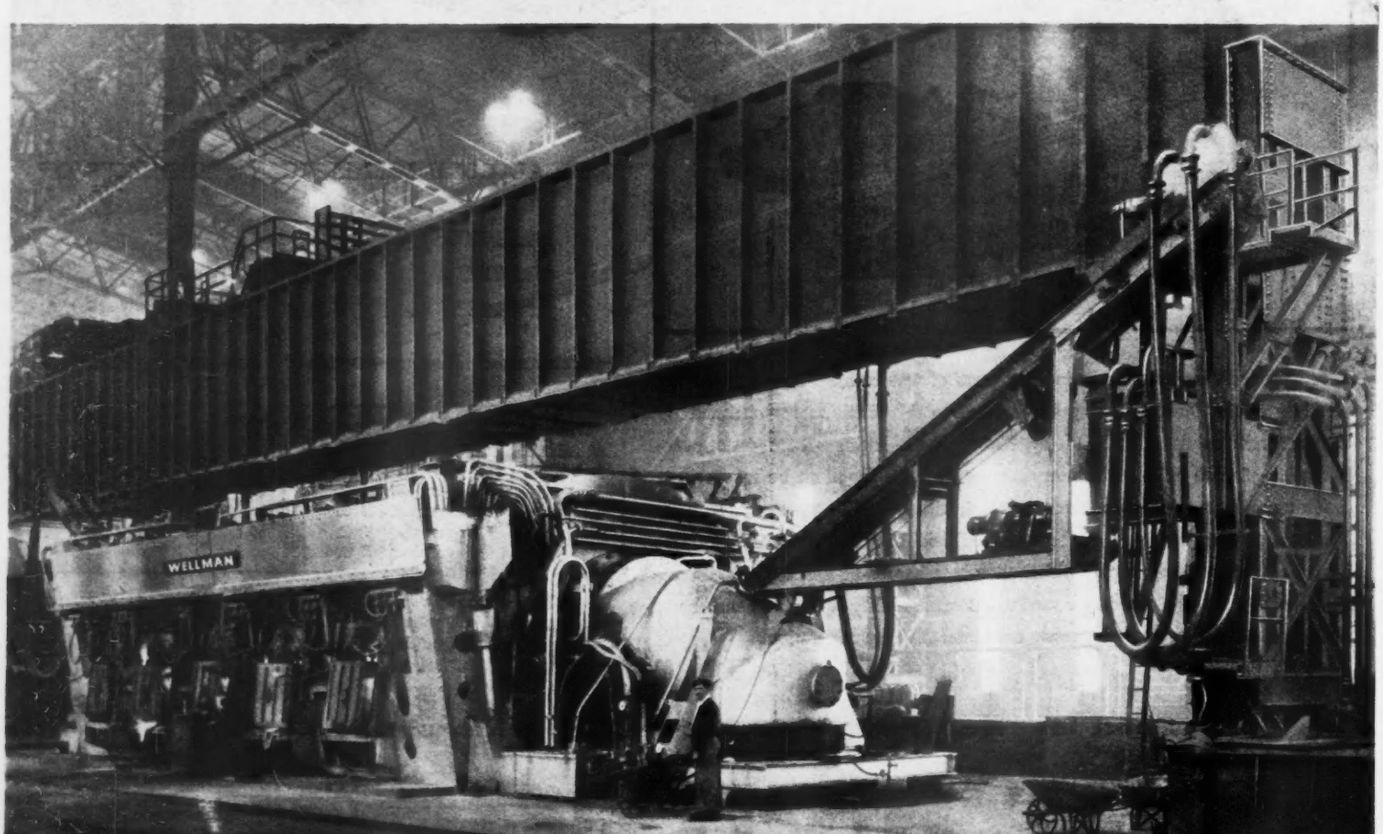

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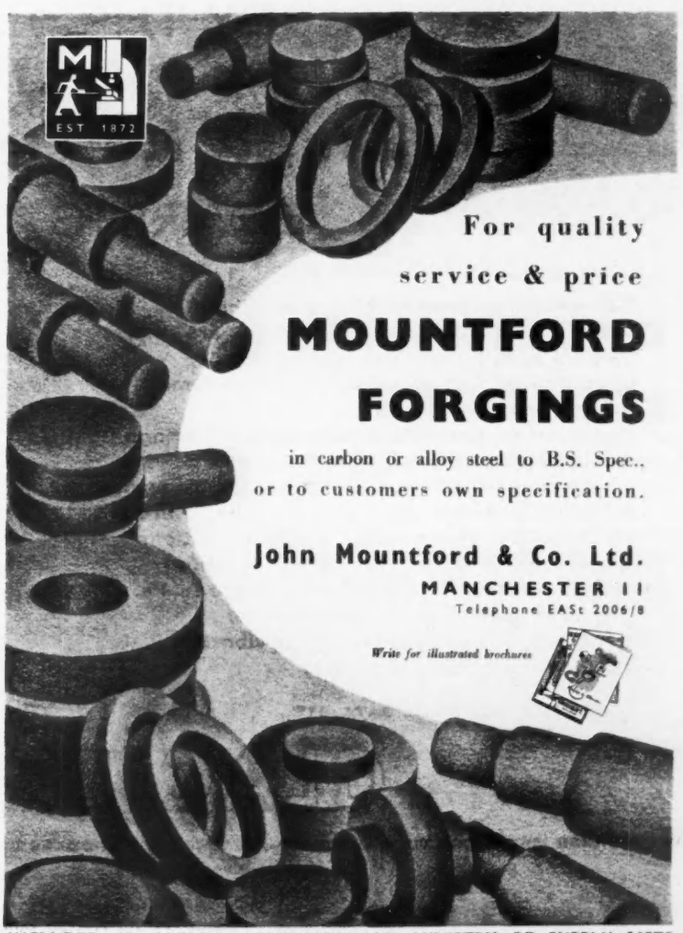

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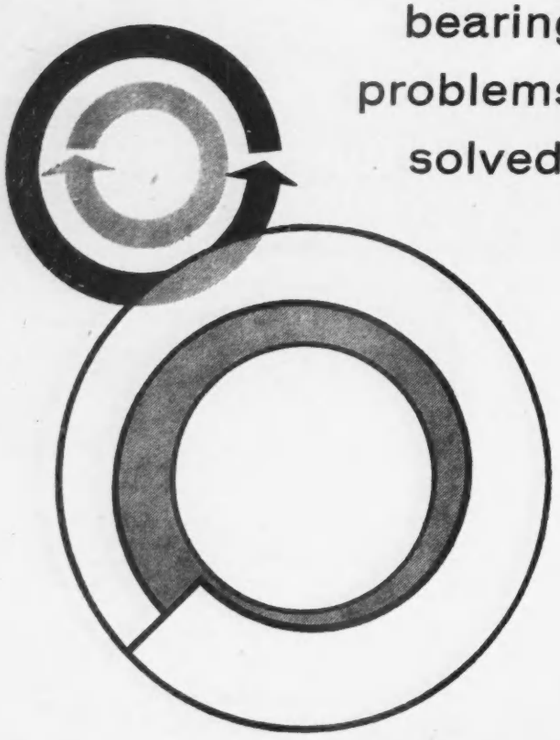

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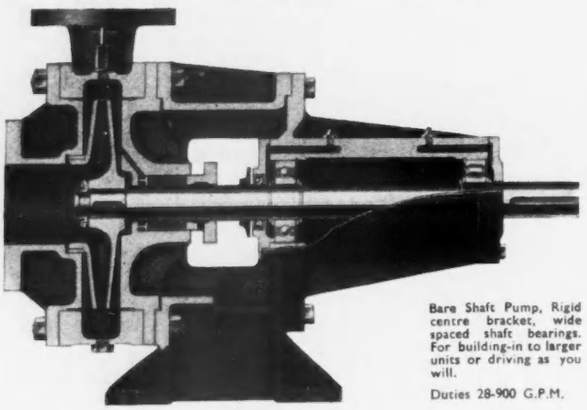

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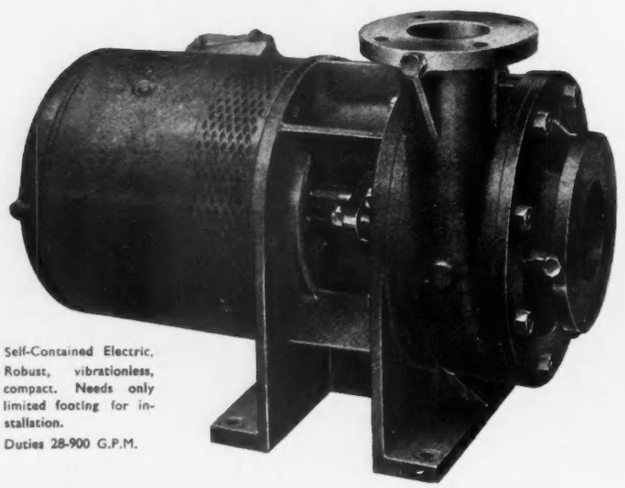

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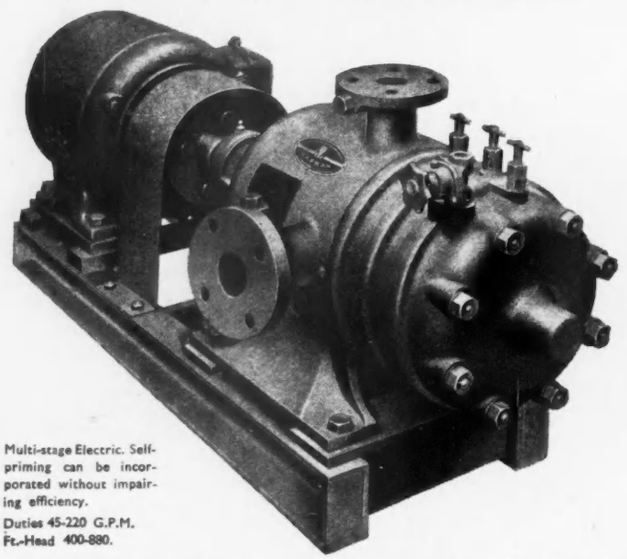

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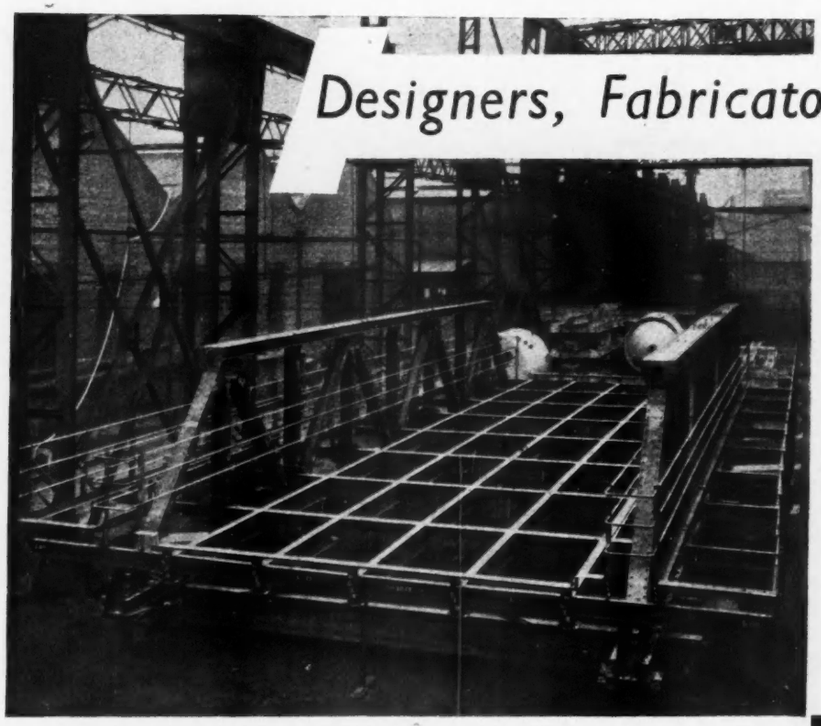

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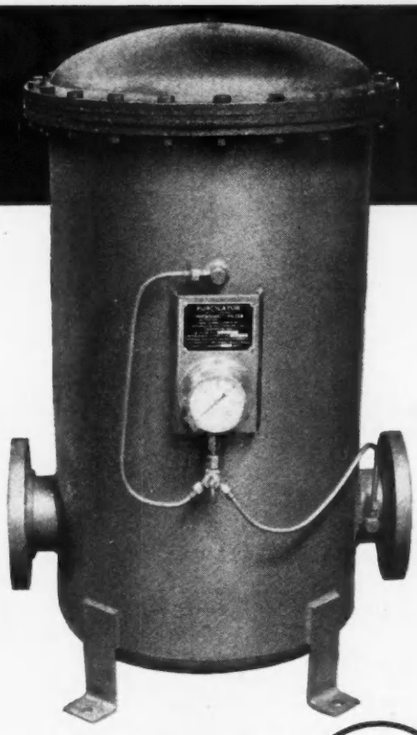

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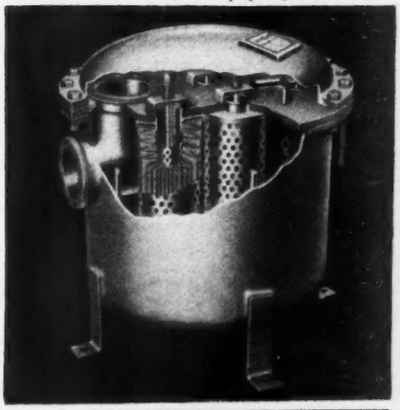

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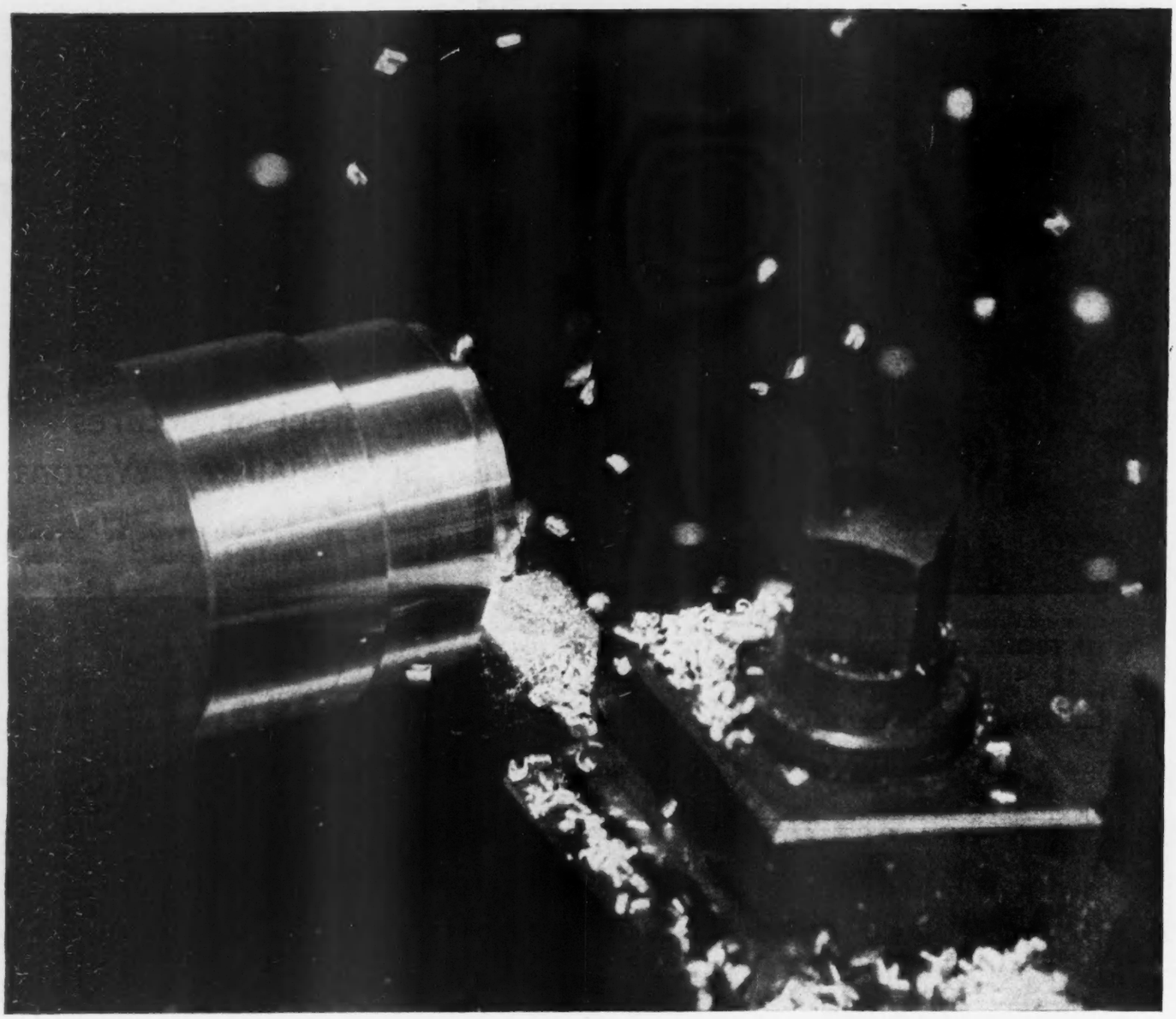

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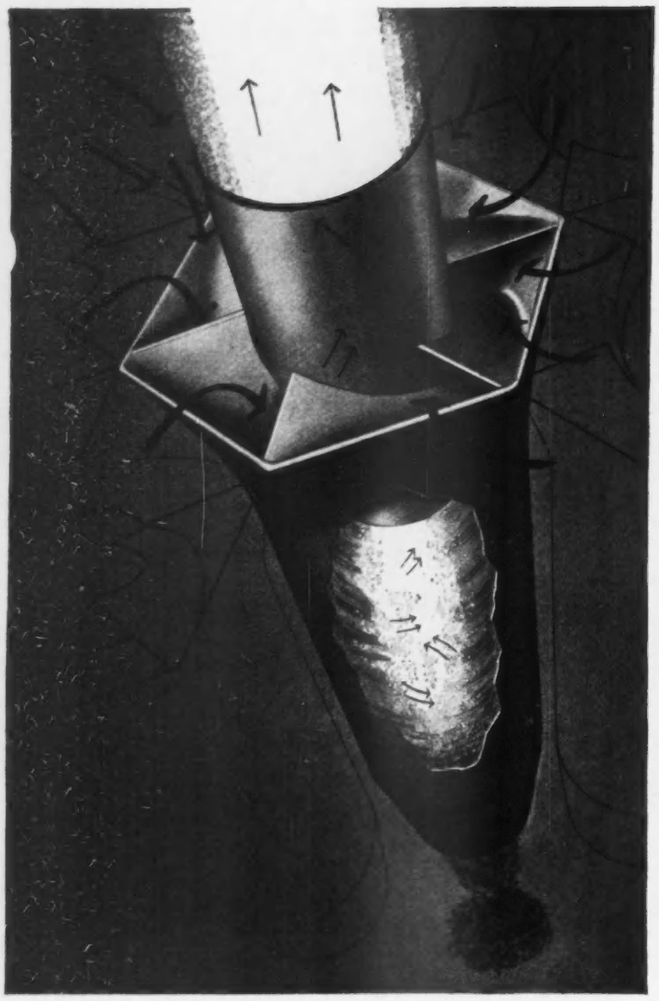

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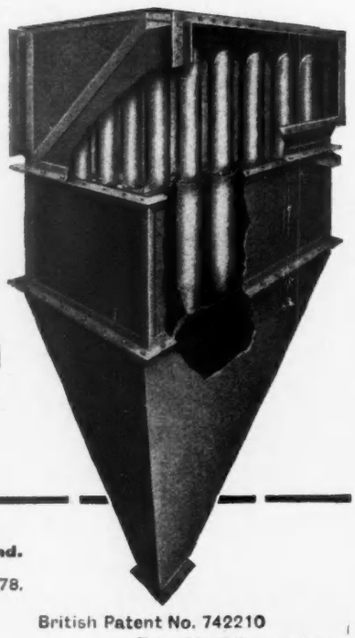

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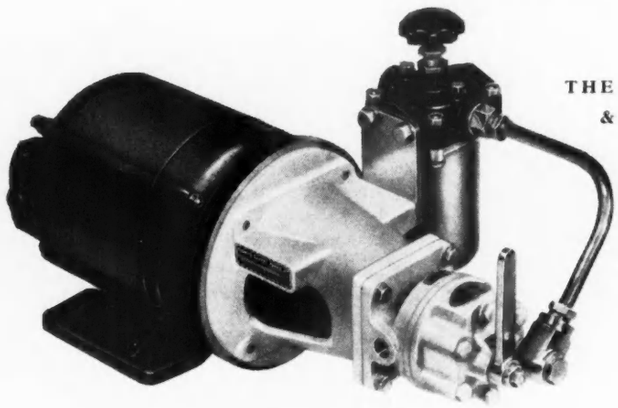

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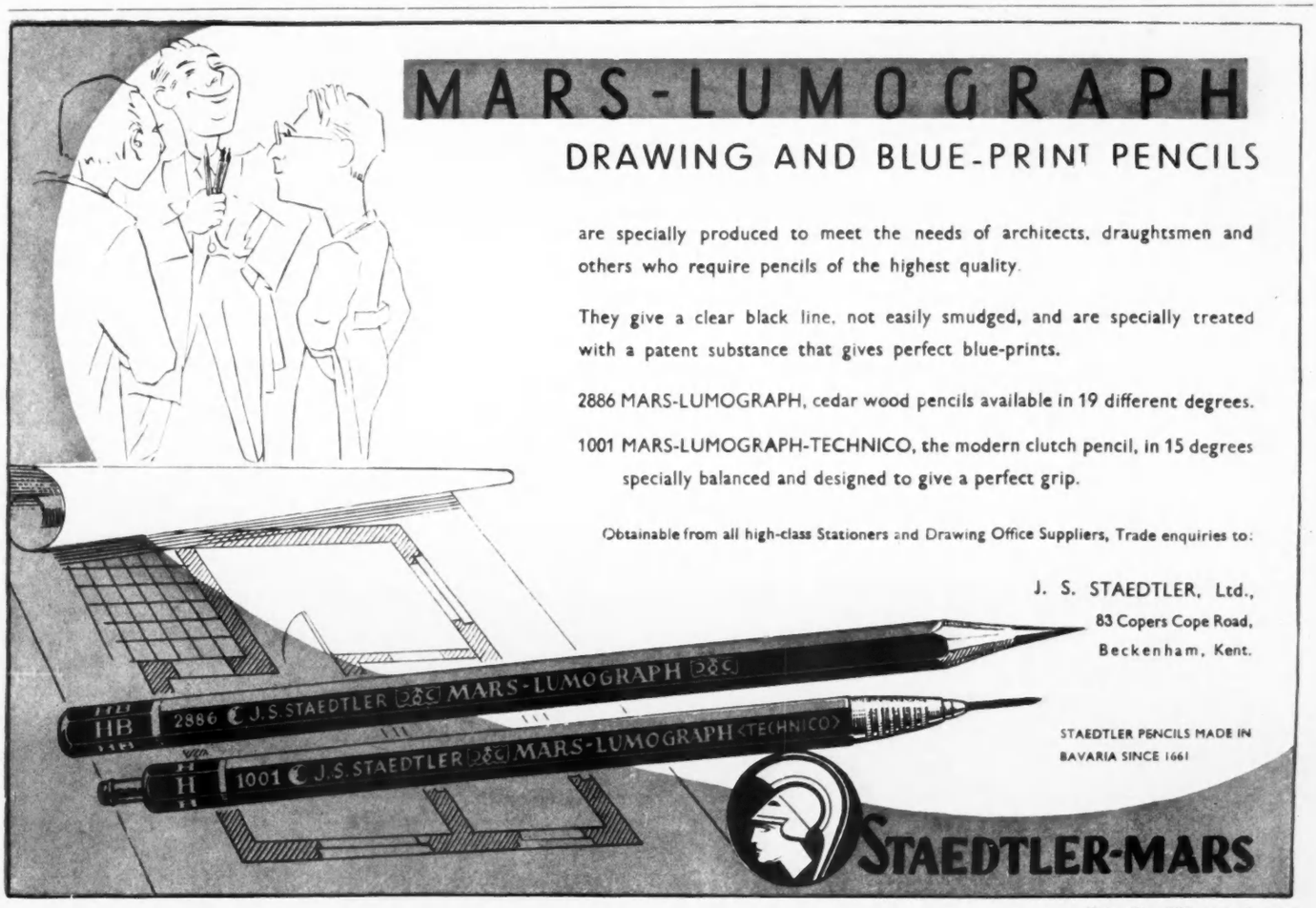
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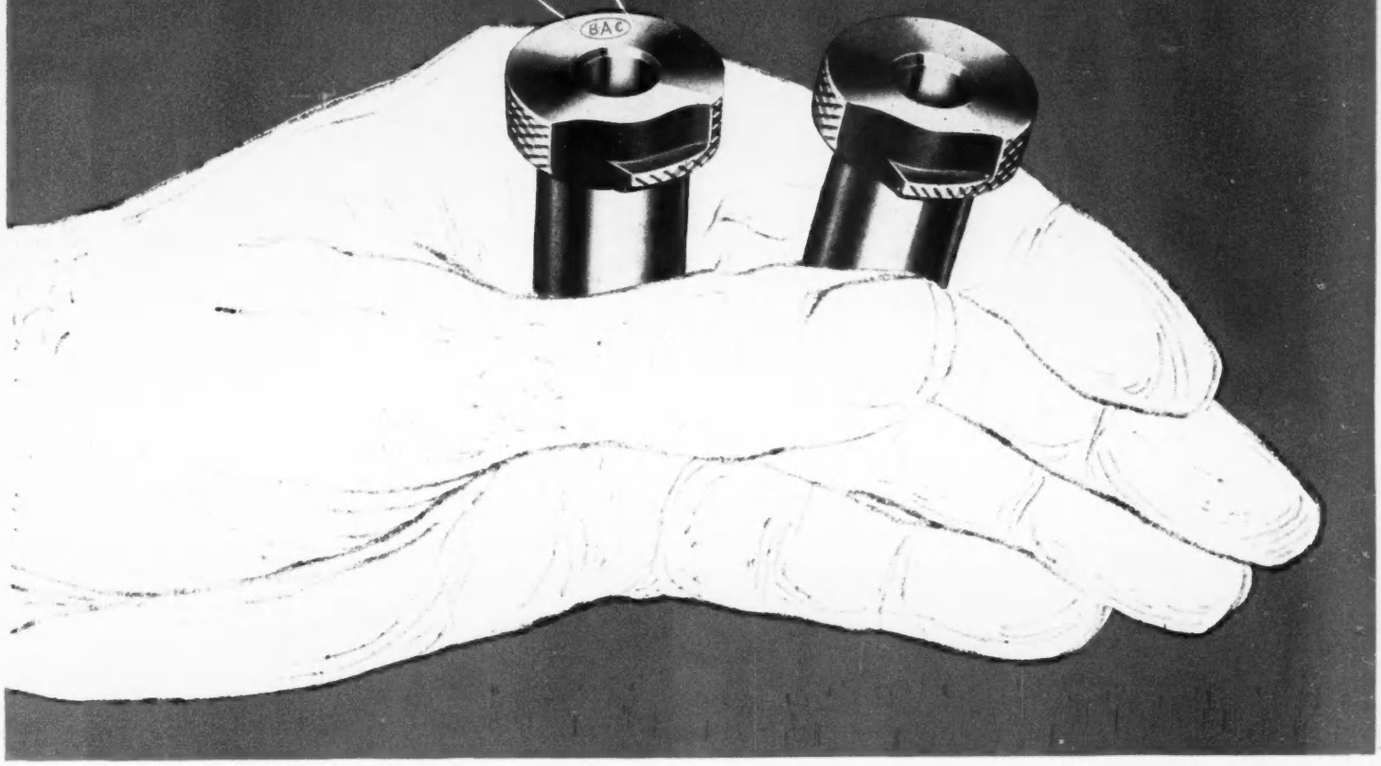

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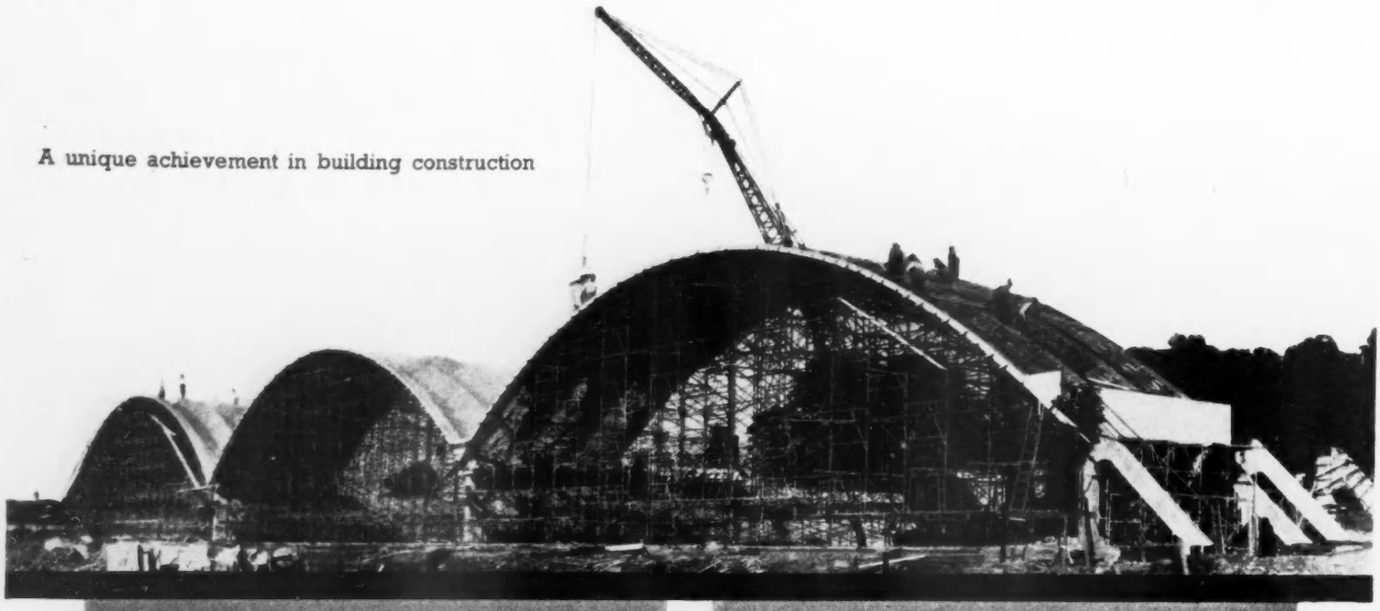

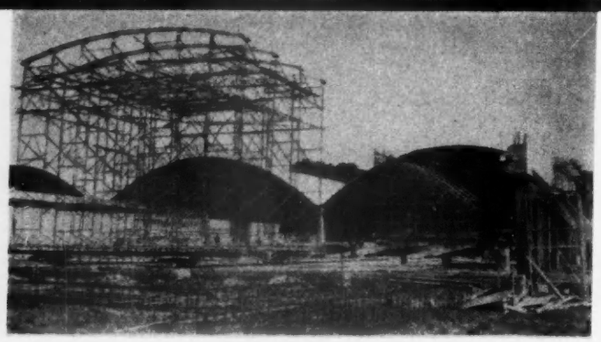

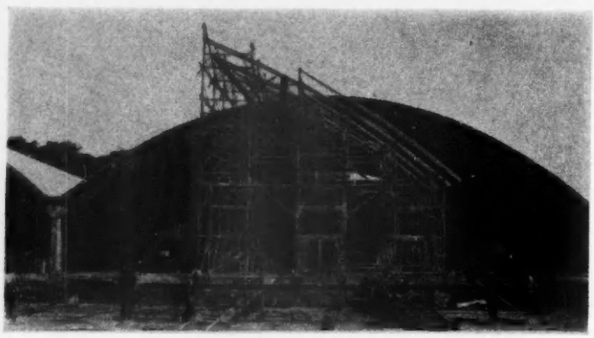

Leggat's achieve a 7 day 'pour and strike' cycle for each 3 span 25 foot section of these Ctesiphon Warehouse roofs at Paisley.

These pictures show the construction of two warehouses each with 3 roof spans of 100ft. for Messrs. Chivas Brothers Ltd., Scotch Whisky Distillers and Exporters, at Paisley by Messrs. Hugh Leggat Ltd., of Glasgow. The roofs are of Ctesiphon Construction and consist of 2½" thick reinforced concrete corrugated arch shells each spanning the full 100ft. Each corrugation has a pitch of 8ft. 4ins. and an overall depth of 2ft. 2½ins. A pre-requisite in designing a scaffolding mobile of this character is the high degree of accuracy required; the whole arrangement working to a tolerance of ⅛".

Its effectiveness may be judged from the fact that a working cycle of only 7 days was achieved for the completion of each section of 3 spans by 25ft. of the roof shell.

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SCAFFOLDING

in a supporting role

Safway used throughout. With the exception of the shaped crossheads and bogies standard Safway equipment was used throughout.

CREDITS

ARCHITECT—S. Lothian Barclay, M.A., A.R.I.B.A., A.R.I.A.S., Glasgow.
CONSULTING ENGINEERS—J. H. de W. Waller, D.S.O., O.B.E., M.Sc., M.I.C.E. London, and A. C. Astor, B.Sc., A.C.G.I., B.I.C., London.
CONTRACTOR—Hugh Leggat Limited, Barrhead, Glasgow. Licensees for Ctesiphon Construction.
PATENTEES FOR ROOF—Ctesiphon Construction Limited, 167 Victoria Street, London, S.W.1.

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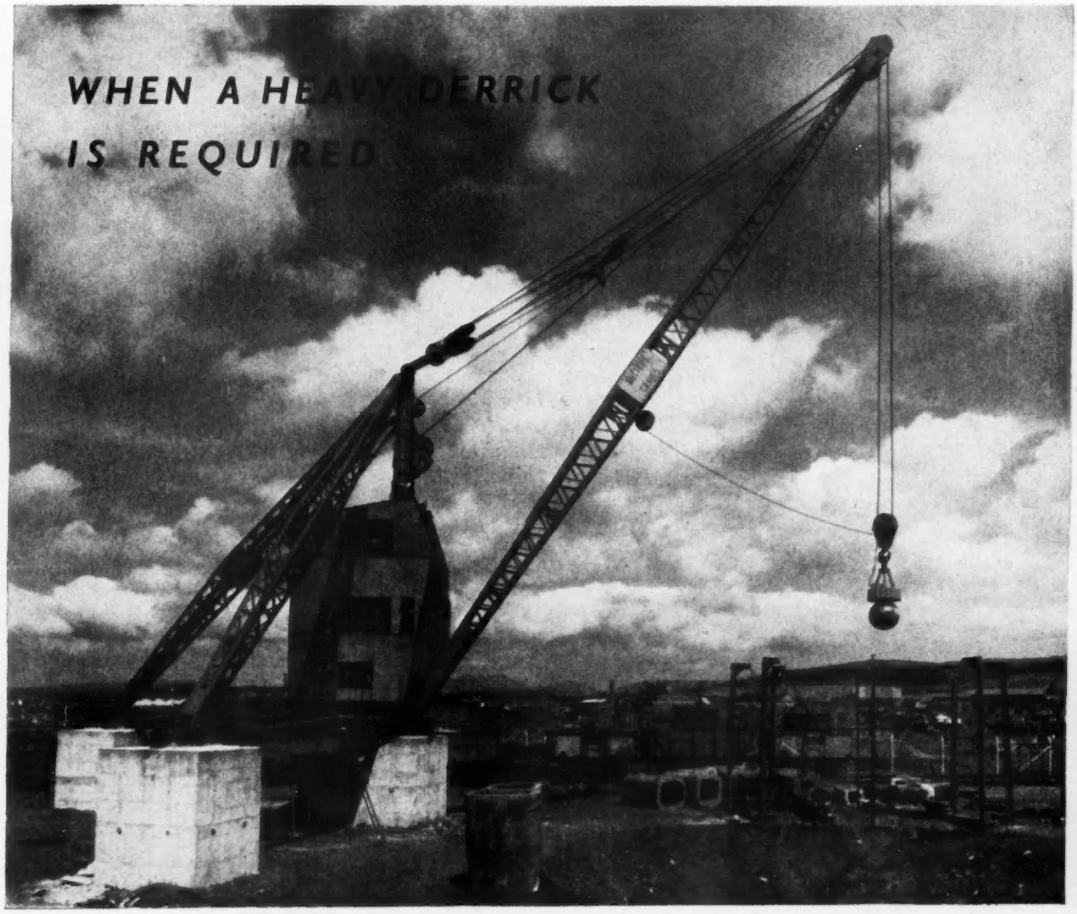

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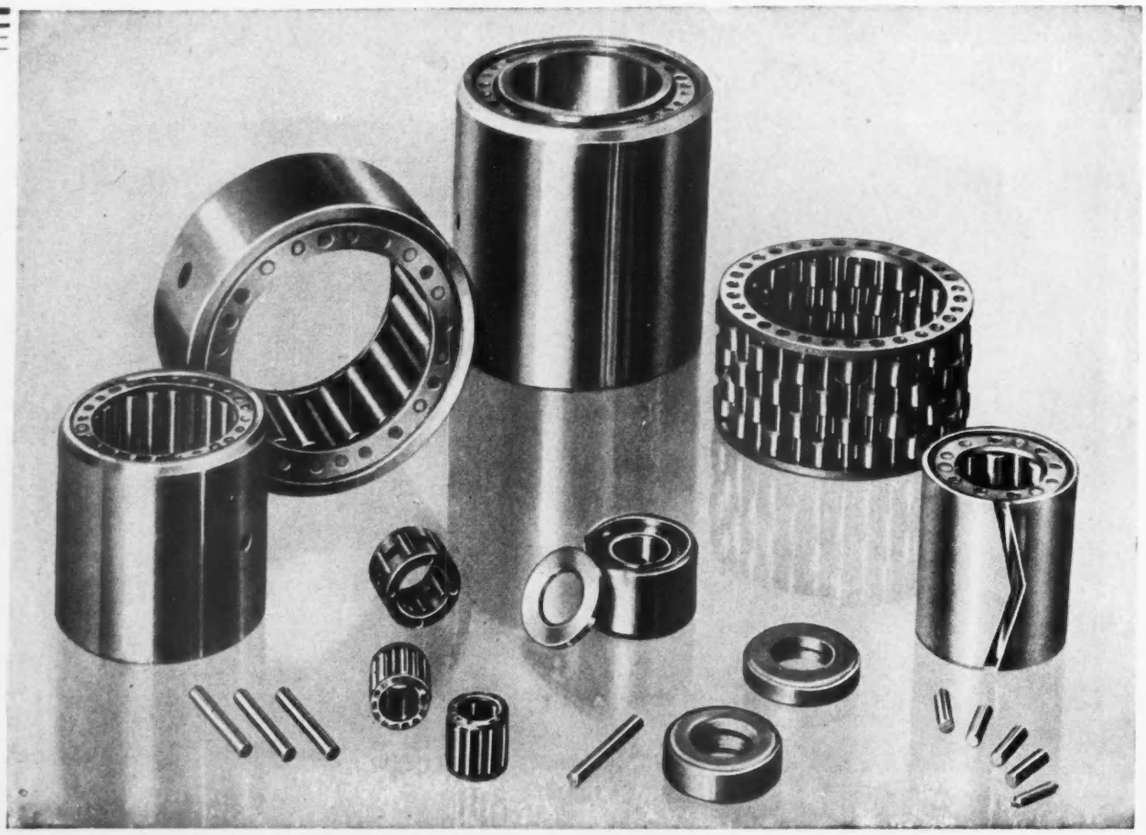

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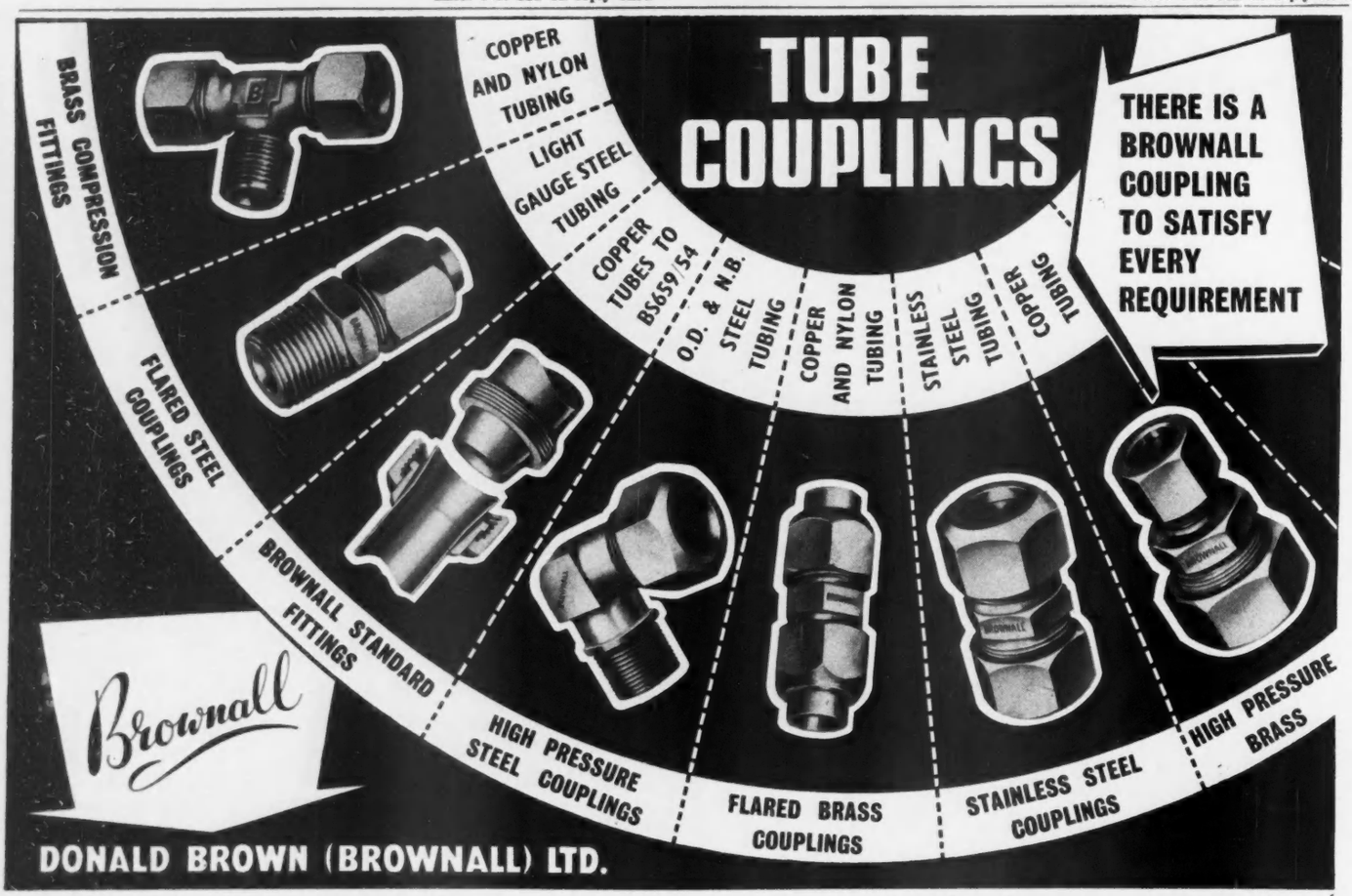

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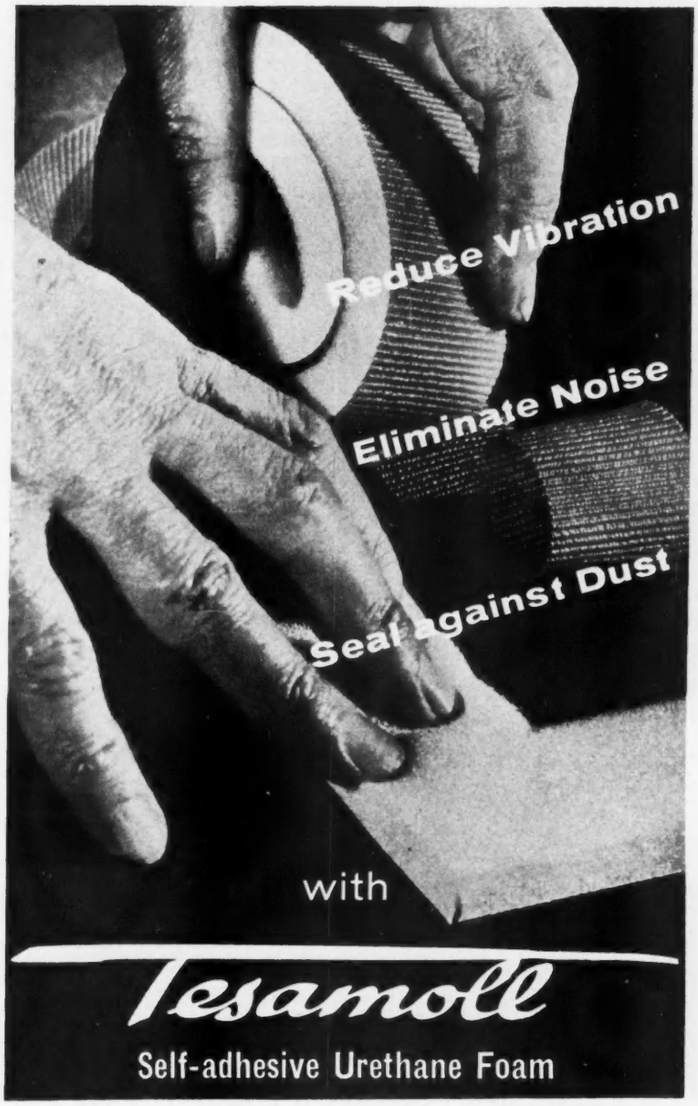

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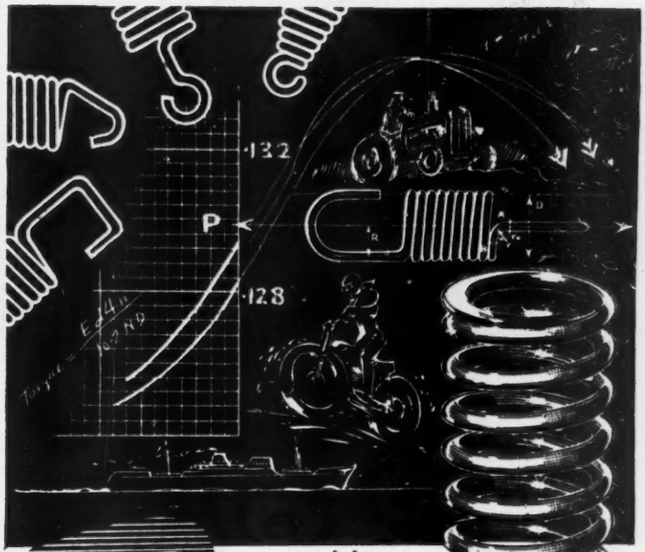

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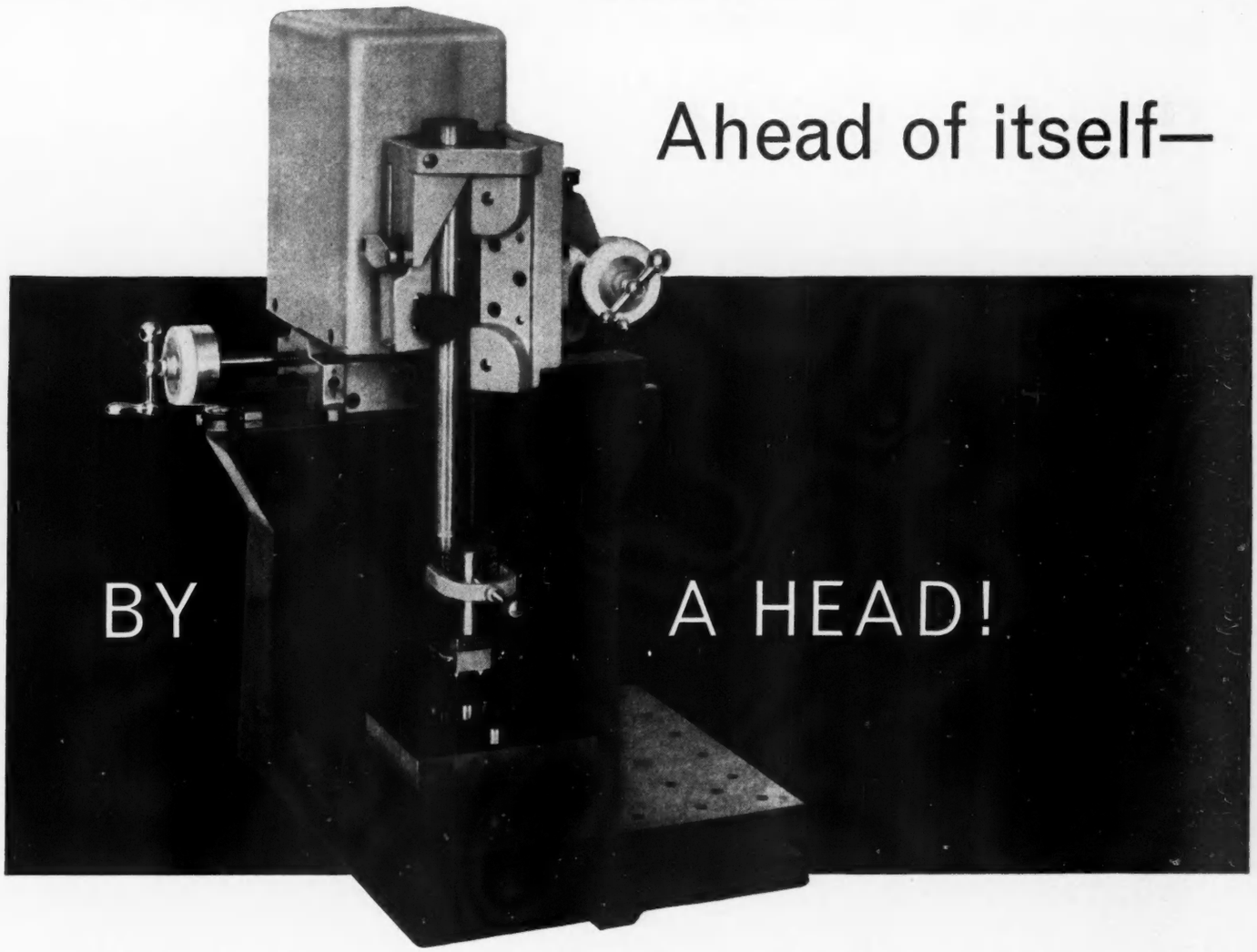

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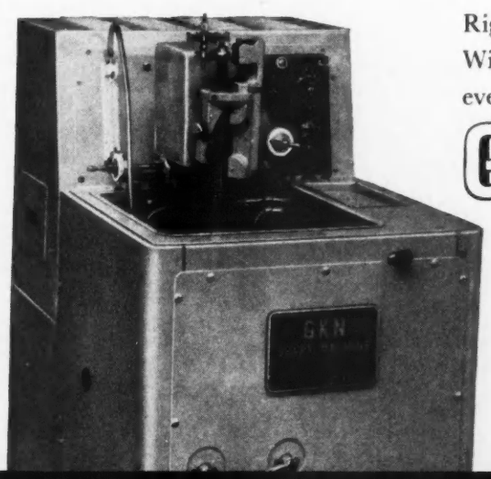

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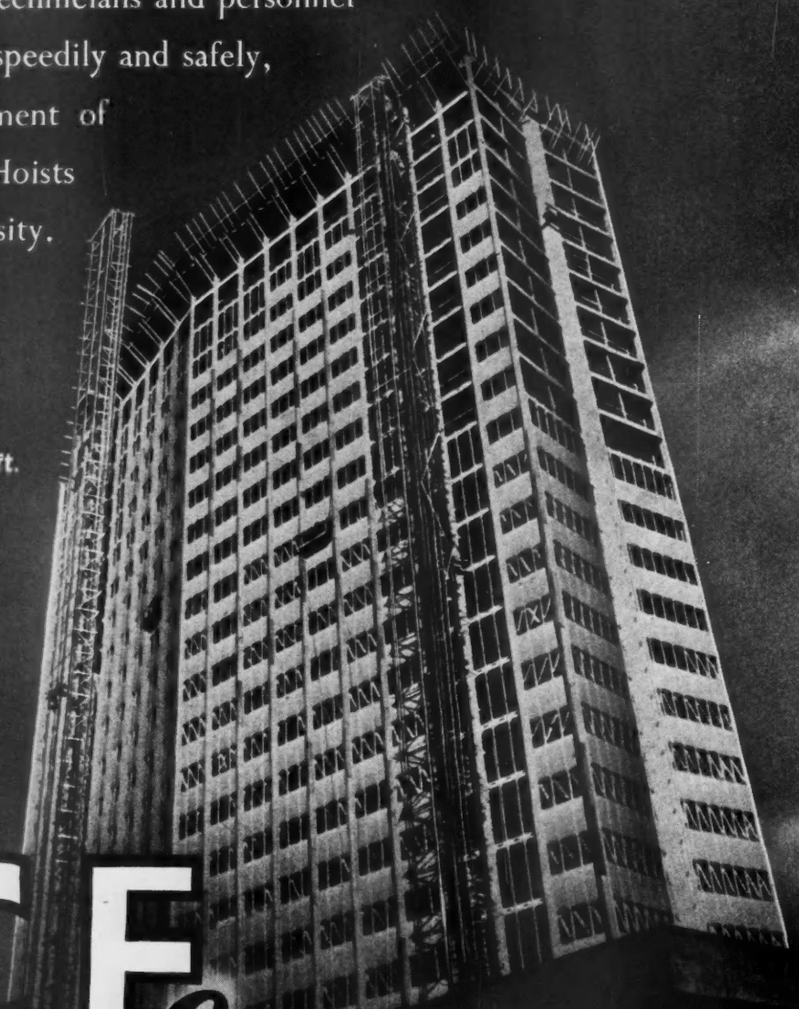

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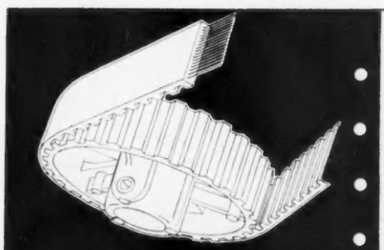

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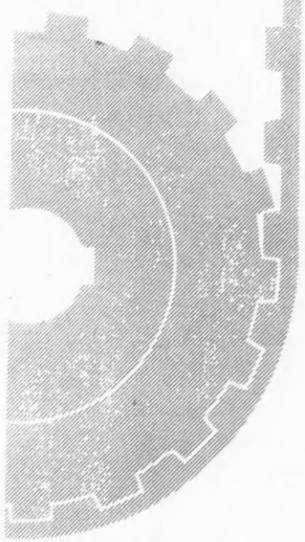

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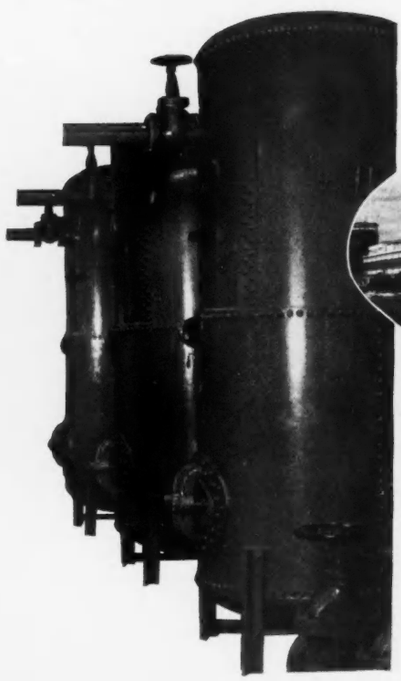

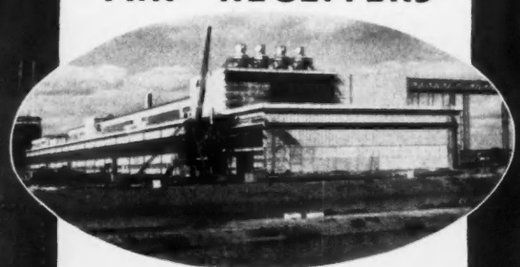

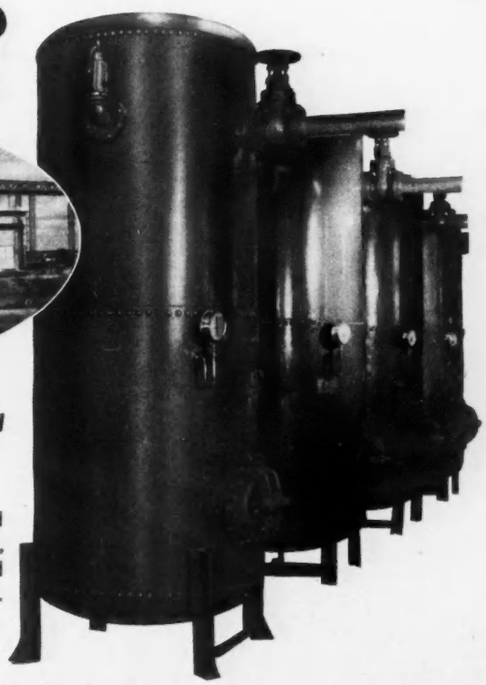

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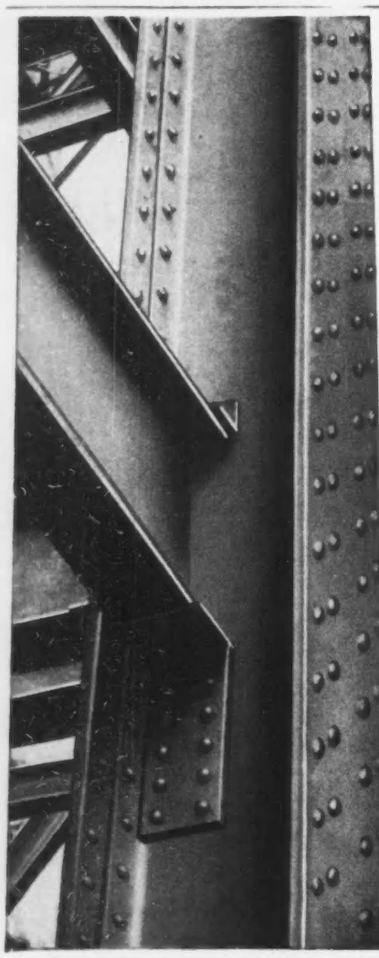

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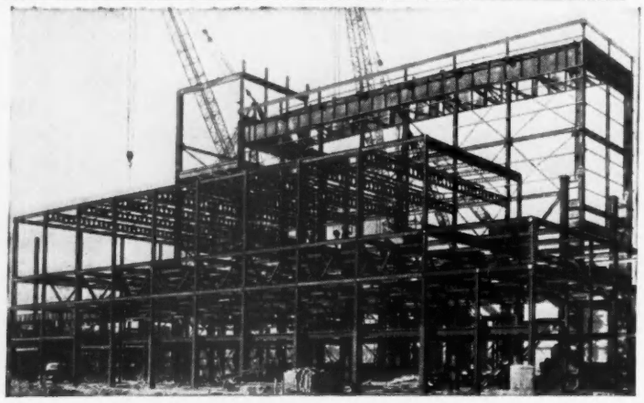

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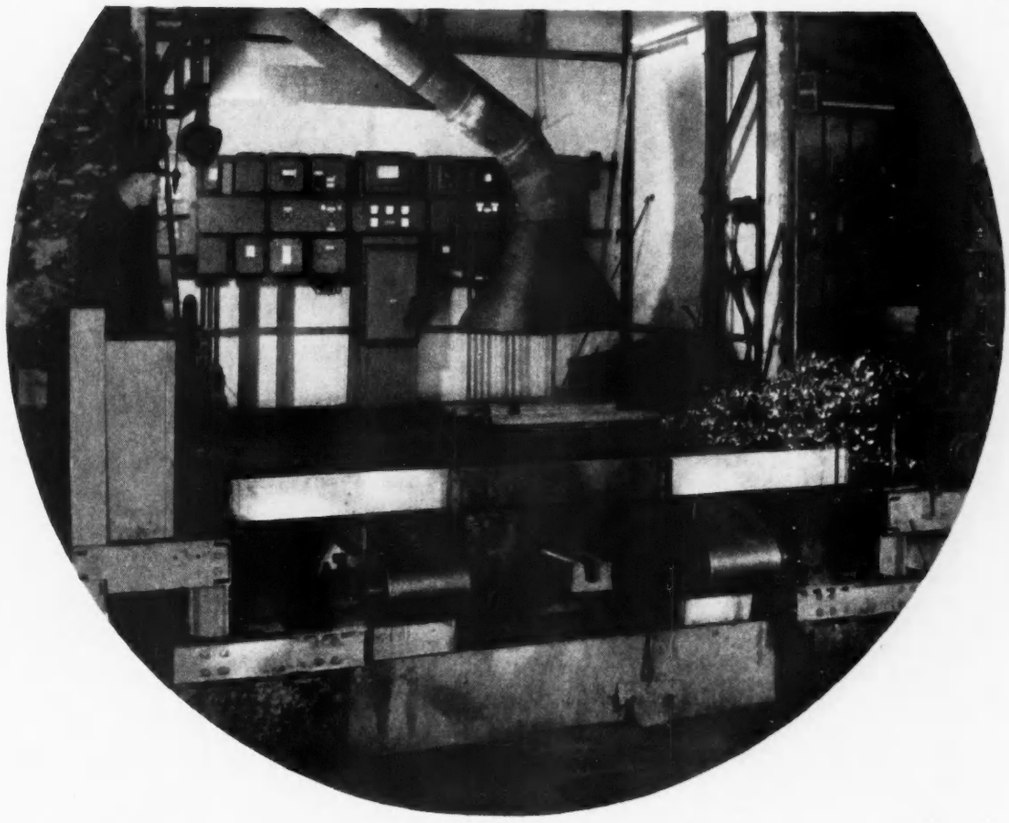

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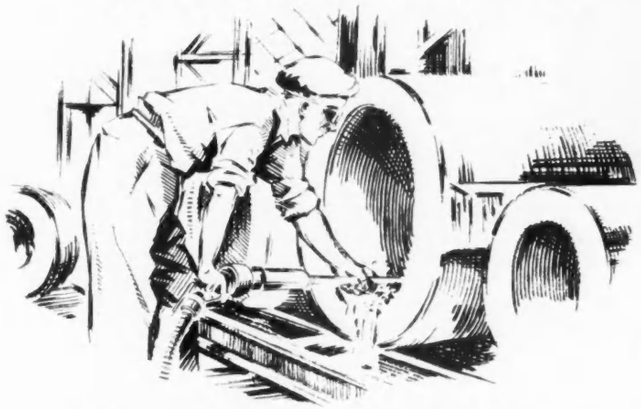

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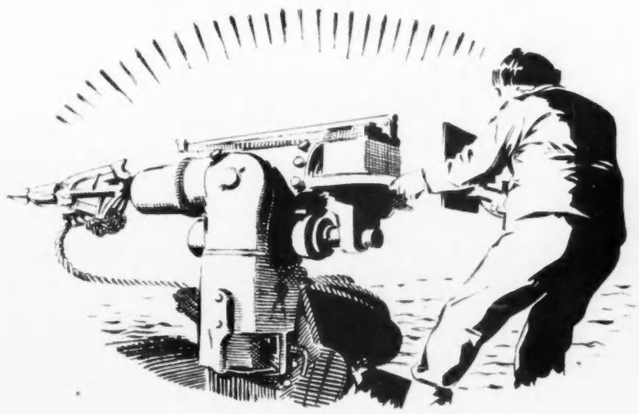

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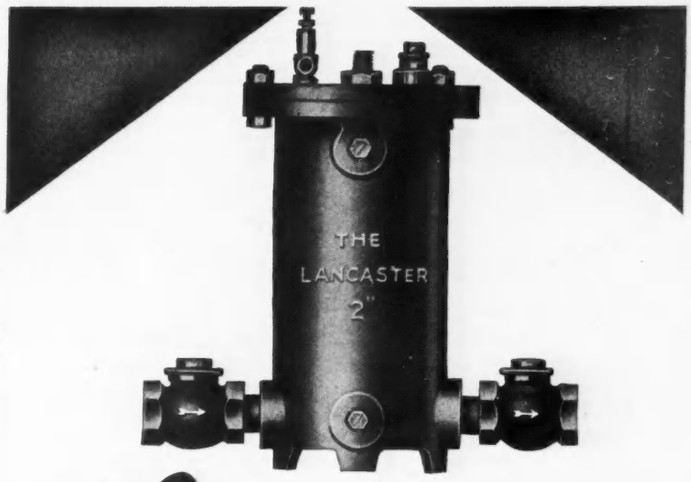

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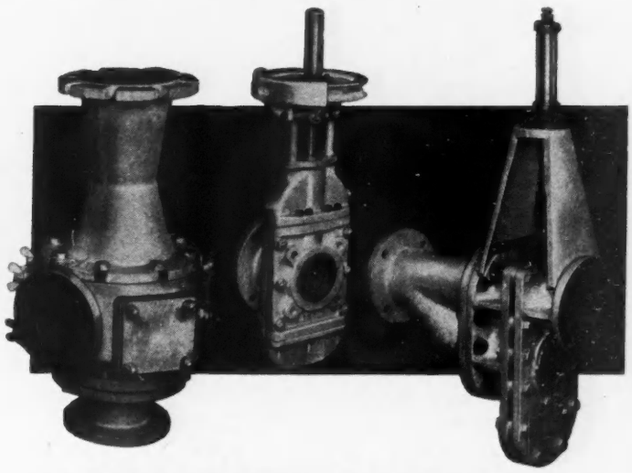

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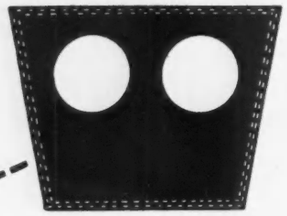
the GROMMET story



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Grommet construction makes the most efficient use of high tensile cords to produce the strongest V-belts yet made. For grommet construction ensures that *all* the cords of a belt share the load *equally* — which is the condition for maximum transmitting efficiency. Furthermore, a grommet, being an endless loop of high tensile cords, has no joints to weaken the belt, no overlapping sections to stiffen it.

2 MORE GRIPPING POWER

Grommet construction ensures that the belt exerts full driving grip on the walls of the pulley groove, for there are no central cords to dip and 'dish' the belt, pulling it away from the walls under load. This extra driving grip allows heavier loads and prevents belt slip.

3 MORE OUTPUT FOR ELECTRICITY CONSUMED

Despite its superior strength, a grommet is the most flexible V-belt load carrying device yet developed. Thus the belt runs cool and absorbs minimum energy in flexing around the pulleys. This saving in power appears in extra pay-load for electricity consumed.

4 LONGER BELT LIFE

Operating with a higher safety factor than ordinary V-belts, BTR grommet V-belts last longer because they are stronger and also because being so flexible they are subject to little strain in flexing round the pulleys.

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Patented in Great Britain by BTR Patent No. 567406

BTR Industries Ltd HERGA HOUSE, VINCENT SQUARE, LONDON S.W.1 *Telephone: VICtoria 3848*

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That is why so many lighting installations incorporate L.E.F. Raising and Lowering Gear.

When planning new lighting installations, remember that special consideration must be given to the maintenance of lights sited high up.

There is no more practical way of dealing with these than by the installation of L.E.F. Raising and Lowering Gear. This ingenious contact suspension gear enables lights to be lowered to ground level for maintenance and raised again. An important factor from the architect's point of view is that L.E.F. gear can be built into the ceiling and is then completely concealed.

Many well-known buildings, street lighting systems, factories, aircraft hangars, etc., have L.E.F. Raising and Lowering Gear. It is the complete answer to difficult light maintenance problems, but be sure to consult London Electric Firm at the planning stage so that they can meet your technical requirements.

LEICESTER UNIVERSITY—Percy Gee Building

This hall is an excellent example of the concealed fitting of L.E.F. Raising and Lowering Gear which is used for each of the lights. Close liaison by L.E.F. with the contractors from an early stage resulted in a trouble-free installation.

Architects: Thomas Worthington & Sons, Manchester.
Contractors: Witcombe & Blackwell, Ltd., Leicester.
Photograph: Thomas-Photos, Oxford.
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L&F **LONDON ELECTRIC FIRM LTD., South Croydon, Surrey. Telephone: Uplands 4871**

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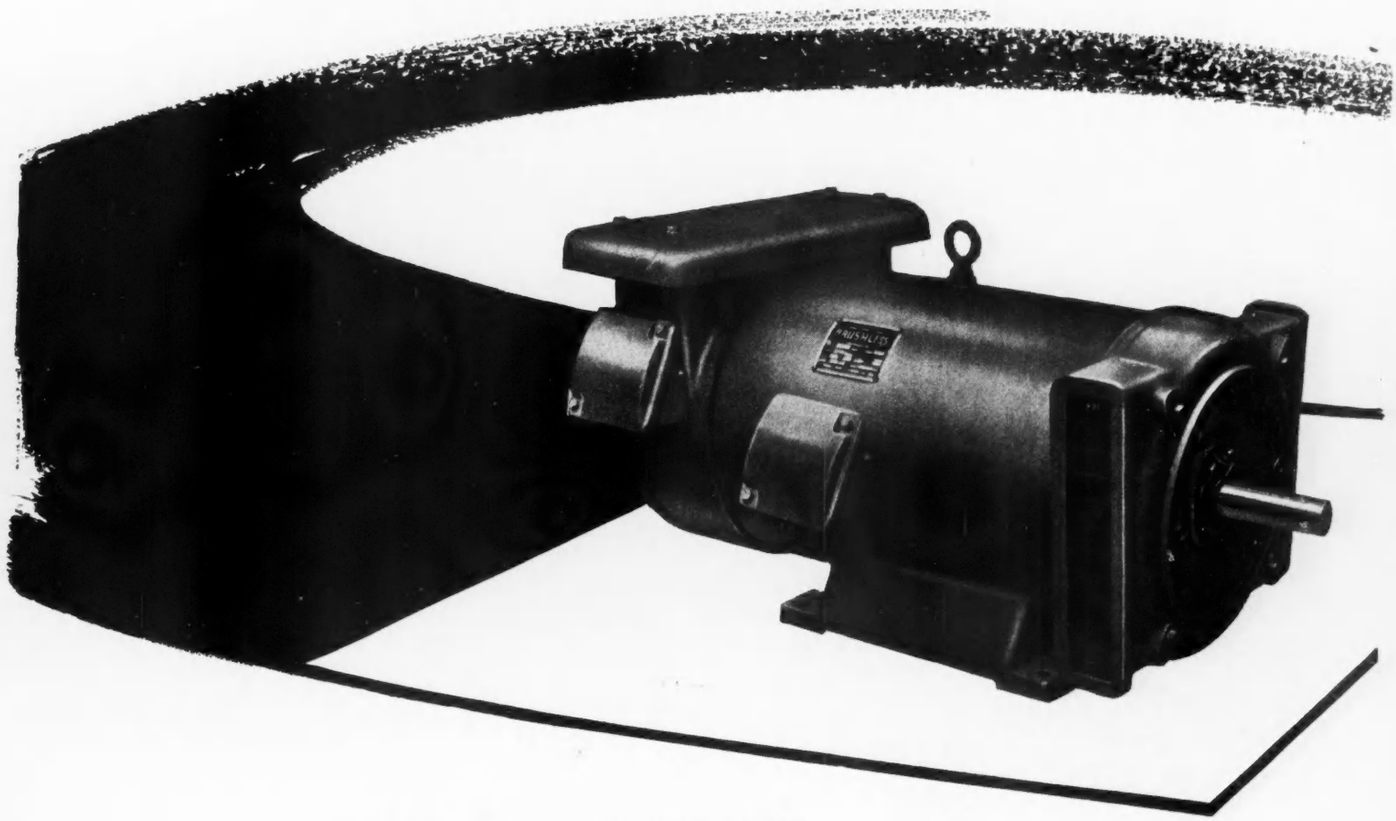
with NO external control gear



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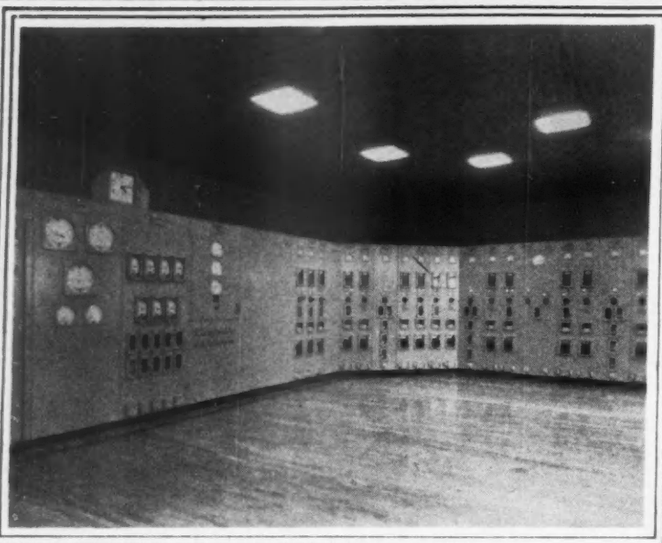

Main control room at Lackenby Beam Mill

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Main 11-kV switchgear at Lackenby Beam Mill

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The result of long research and development, the L 2000 has been subjected to exhaustive tests which have proved most satisfactory.

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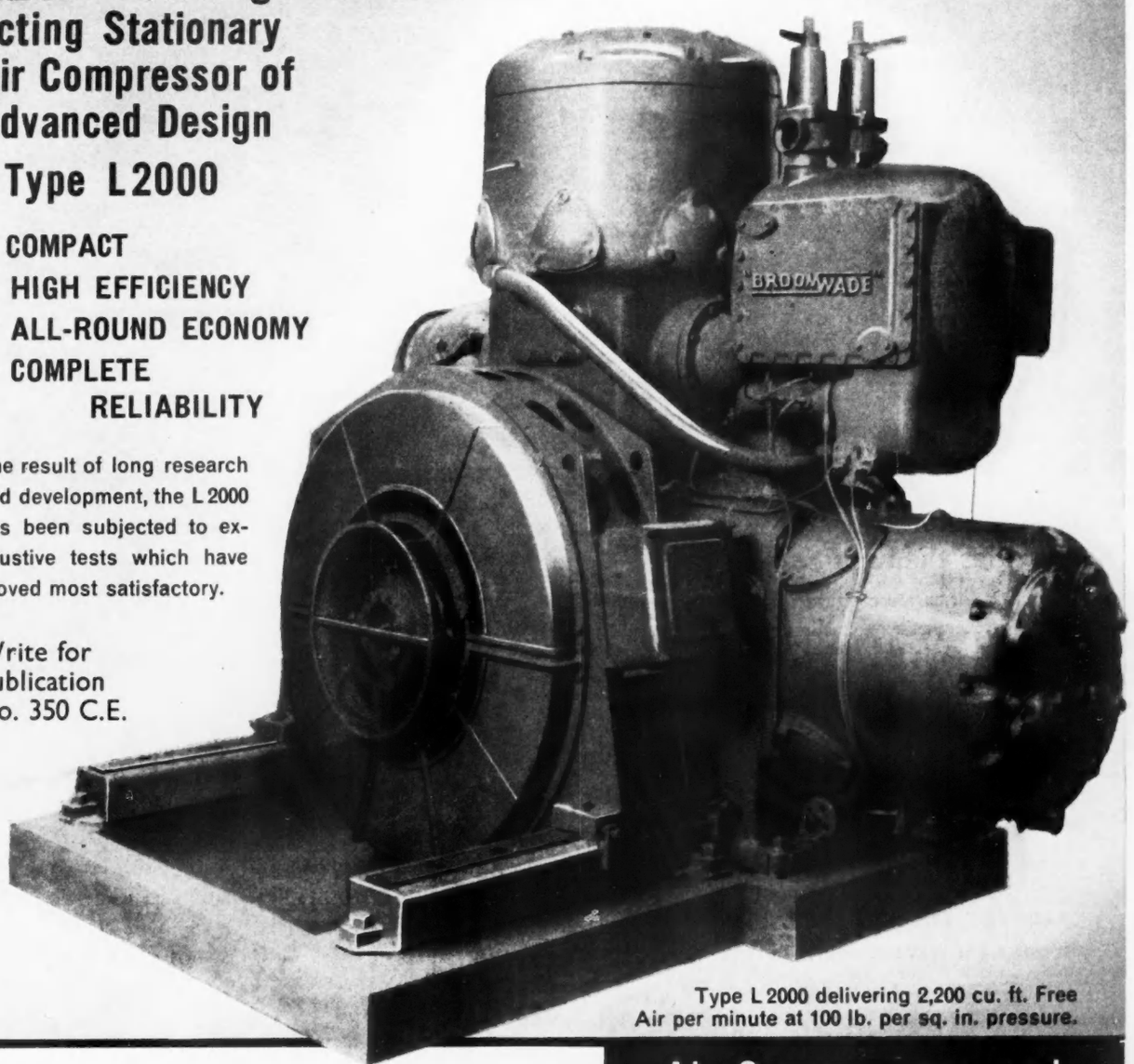

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There's talk of Sykes in the boardrooms...

The works director of a well-known British company recently telephoned the Sykes factory at Staines. He explained that his firm wished to increase the horse-power of an existing engine without altering the structural design of the gear box. Was it possible, he wanted to know, to achieve this by the use of Sykes double-helical gears; would the consequent increased power give rise to undue noise and vibration; and, most important, would the modification step up his production costs?

Fortunately for him, this was the sort of problem which Sykes are exceptionally well qualified to tackle. Years of work at their main business of supplying first-class gear generating equipment—hobbers, shavers, shapers, cutters—have left them with a rich store of practical experience and expert knowledge. And through their Technical Sales Advisory Service, this accumulated knowledge is available to anyone who wishes to benefit from it.

In this particular case, for example, Sykes sent a technical representative to examine the designs for the job. As a result Sykes advised certain additional modifications to the gears; and then—although this was not strictly in their field—their long experience enabled them to suggest how any possibility of noise problems could be avoided by a small internal adjustment to the housing.

Talk to SYKES about gear production

W. E. SYKES LTD · STAINES · MIDDLESEX · ENGLAND and associated companies
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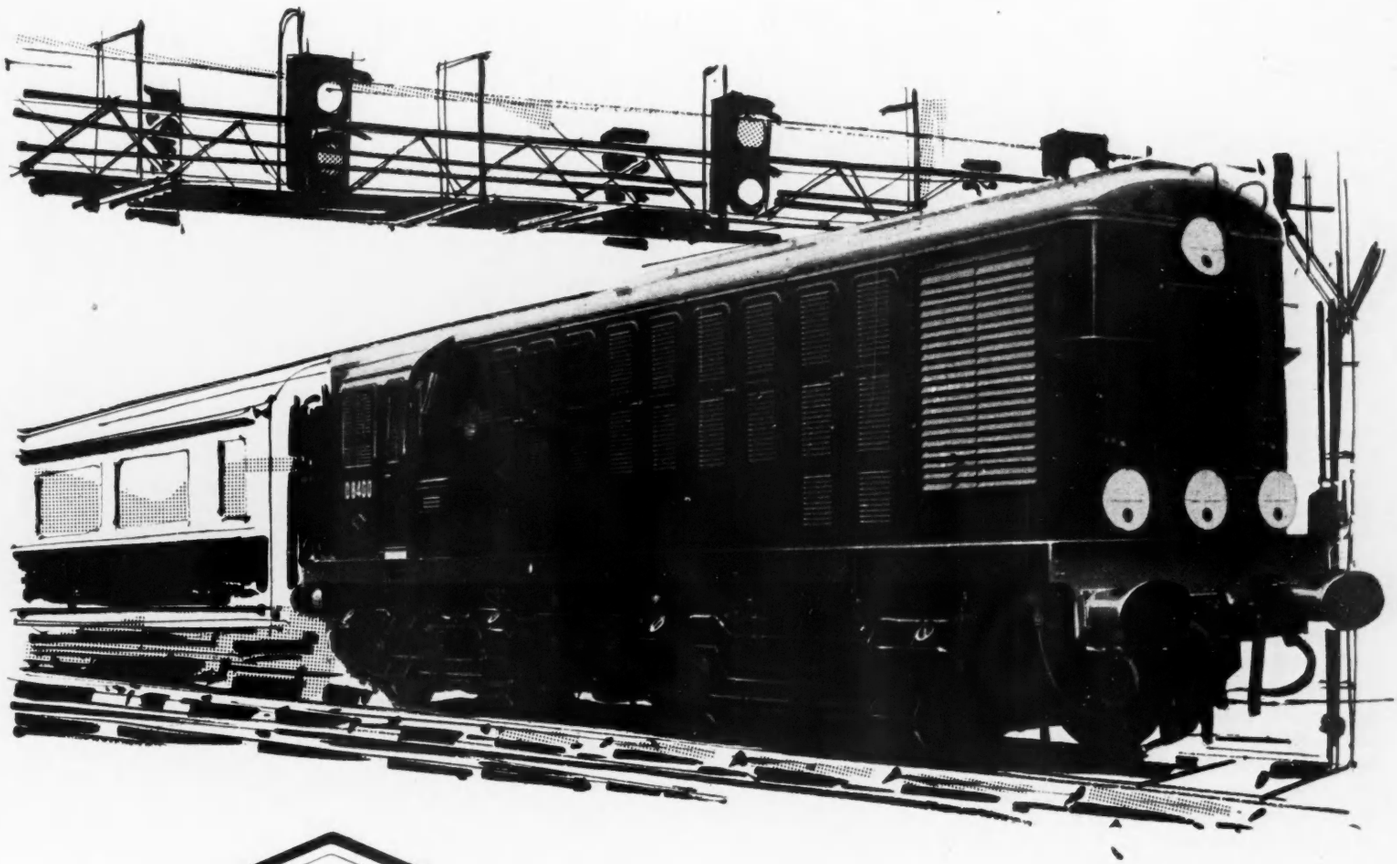

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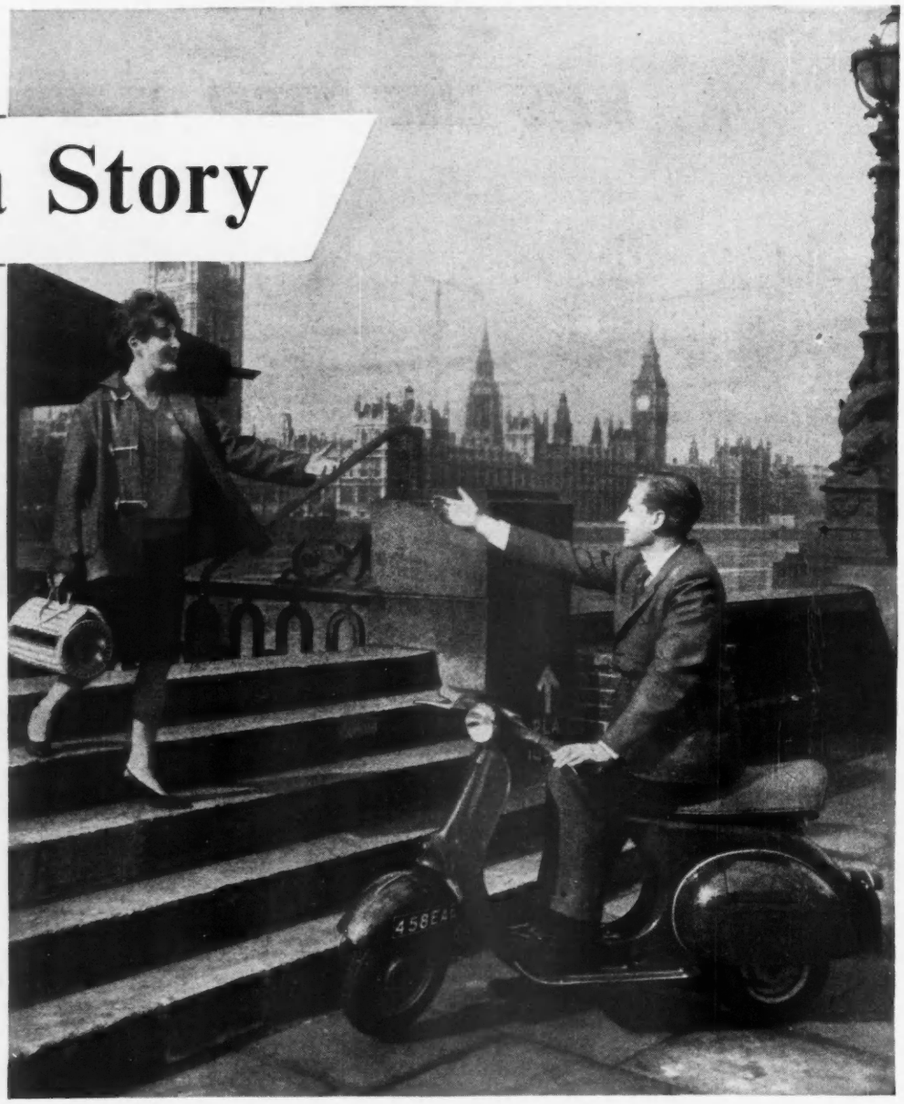
The Vespa Story



"Out of darkness cometh light"

Post-war Italy was bankrupt—physically, politically and economically it was a scene of desolation. Yet it was in this unprepossessing economic environment that Dr. Piaggio in Genoa started an enterprise which has revolutionised post-war personal travel throughout the world. Within twelve months of Mussolini's mutilation, he had produced over two thousand of the now world-famous Vespa Motor Scooters. Within ten years he was to make a million. Now, the Italian Vespa Company employs more than 4,000 workpeople and the robust little Vespa has completely democratised personal transport. Workmen in factories, doctors on their rounds, bankers, stockbrokers and film stars in every country are all proud Vespa owners. In fact, the Vespa has eradicated motor car snobbery and made tens of thousands of womenfolk motorists for the first time.

At home, pre-war, the name of Douglas was famous in the motor cycle world, but in the immediate post-war years this famous Douglas Company at Bristol had fallen on evil times. It was in the hands of the receiver when Claude McCormack, a Coventry Motor Engineer, took over what seemed an insuperable task of rehabilitation. By chance, whilst holidaying in Italy, he saw the Vespa, and although in charge of a bankrupt firm he nevertheless persuaded the then well-established Italian Vespa Company to grant manufacturing rights to Douglas. The Vespa brought success to the bankrupt Douglas organisation; the jobs of more than a thousand people were saved; bank overdrafts were repaid; shareholders realised unhoped-for prices for shares worth previously only a few coppers, and the Douglas Company became worthy of purchase by the powerful Westinghouse Brake and Signal Company Ltd. Thus the birth of the British Vespa took place also in an environment of economic desolation. Now the Douglas Company at Bristol employs nearly 2,000 people and the output of the Douglas Vespas has topped the 100,000 mark. Quite recently the 'Financial Times' reported that the domination of the United Kingdom scooter market by imported models looks like ending. United Kingdom production has increased 100% in the past twelve months and imports only a quarter, whilst British exports to the United States, the Commonwealth and Scandinavia are expanding. If any proof is required that trials and tribulations inspire mankind to prodigious effort, surely the Vespa story is a pertinent example.

At Kingswood there is a modern Vespa production line modelled on the motor car industry. Large presses stamp out the framework and overhead conveyors take the chassis and components to the paint and assembly shops.

However, the Vespa's attractive colour coat serves as a protective mantle to the robust and reliable power, transmission and braking systems which lie beneath. The construction of the components for these systems presents many problems for the metallurgist. Most of them depend upon heat treatment, carburising, tempering, etc., which demand very close time/temperature schedules. For this reason most of the furnaces are on automatic temperature control where thermocouples

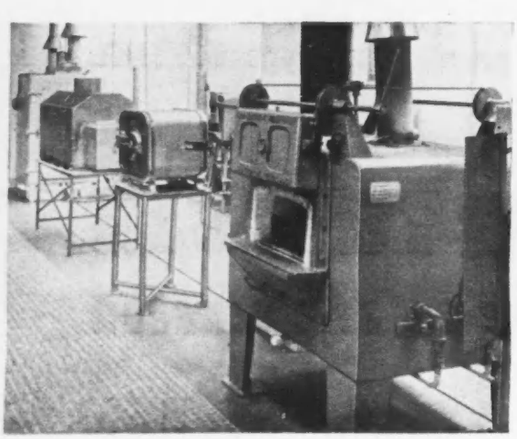


Fig. 2. A view of the new industrial gas showroom opened by the South Western Gas Board.

measure the temperature and transmit an electrical signal to control pyrometers which operate valves in the gas supply according to the measured temperatures. This ensures that the temperature never varies from the close limits necessary for correct heat treatment which largely determines the life of the components. The Douglas Company uses town gas supplied by the South Western Gas Board for melting, hardening, tempering and carburising as well as stoving the synthetic paint finishes. For these purposes town gas is the most suitable fuel because its declared calorific value lends it well to precise automatic control. Other advantages are, of course, that there are no interruptions for fuel deliveries, and the gas meter provides the simplest and cheapest form of fluid fuel costing.

In the foundry gas is used for core drying, and aluminium alloy melting is carried out in three gas-fired melting furnaces, the molten metal being used for the gravity die-casting of the light alloy components. Crankshafts, gears, etc. require special heat treatment to fit them for their arduous life, and in the Carburising Shop there are three gas-fired muffle furnaces as well as a high-speed tempering furnace. Other non-ferrous components are treated in gas-fired salt bath furnaces.

The standard of finish on the Douglas Vespa is extremely high. The chassis, mudguards, etc. having been assembled, stress-relieved and filled, pass on conveyors into the finishing shop. After being sprayed with a number of priming and finishing coats of paint the components pass, still on conveyors, into a gas-fired infra-red paint stoving oven which was specially designed to suit the awkward shape of the chassis, thereby ensuring that each part of the painted surface received adequate heat. Again town gas was chosen as the fuel because it lends itself more easily to the close time/temperature schedules required to cure the modern synthetic paints. Undoubtedly the large output of Vespa Scooters has benefited from the close co-operation between the South Western Gas Board, the equipment suppliers and the Douglas Company. As part of its service to industrialists in the South West the South Western Gas Board has recently opened an Industrial Gas Showroom where factory executives can inspect working examples of infra-red tunnels, natural draught oven furnaces, muffle furnaces, recirculating ovens, etc. Anyone can bring along the components in which they are interested and try them out with the equipment in advance of purchase. A small pottery kiln is in great demand by schools in the district, and examples of decorated and glazed pottery reflect high credit not only upon the schoolboys and girls but upon the precise time/temperature schedules obtainable with town gas in a relatively inexpensive kiln. In addition, there is a wide range of gas burners together with ancillary equipment such as flame protection and ignition systems where automatic temperature control figures prominently.

This Industrial Gas Showroom is one positive example whereby the Gas Industry through its Industrial Gas Officers at the Area Gas Boards is serving industry—these officers from all over the United Kingdom meet regularly to discuss developments, so that any manufacturer approaching any Area Gas Board has at his disposal the pooled knowledge throughout the country in some 4,000 different trades and industries served by gas. One practical result of this service is reflected in the Douglas plant at Kingswood, Bristol—and the name of Douglas is in turn reflected in the ever-increasing market for its ever popular and glamorous Vespa Scooter.

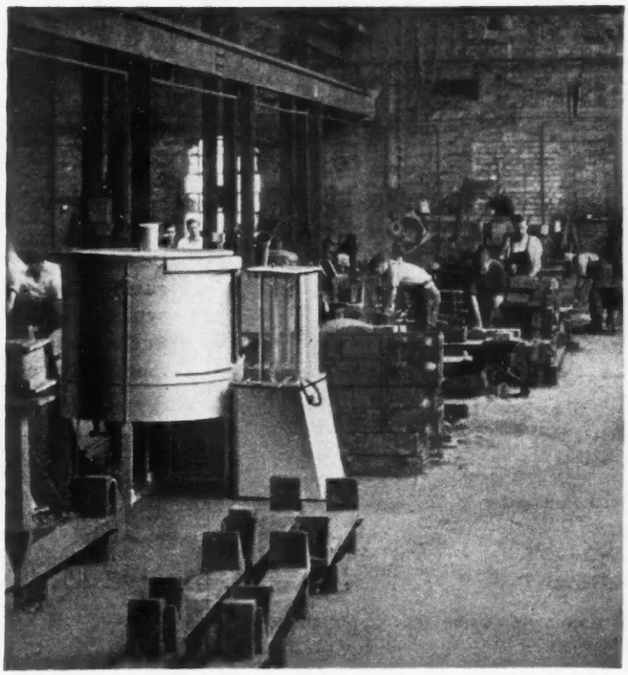


Fig. 4. A view of the gas-heated core drying installation in the foundry of Douglas Engineering (Kingswood) Ltd.

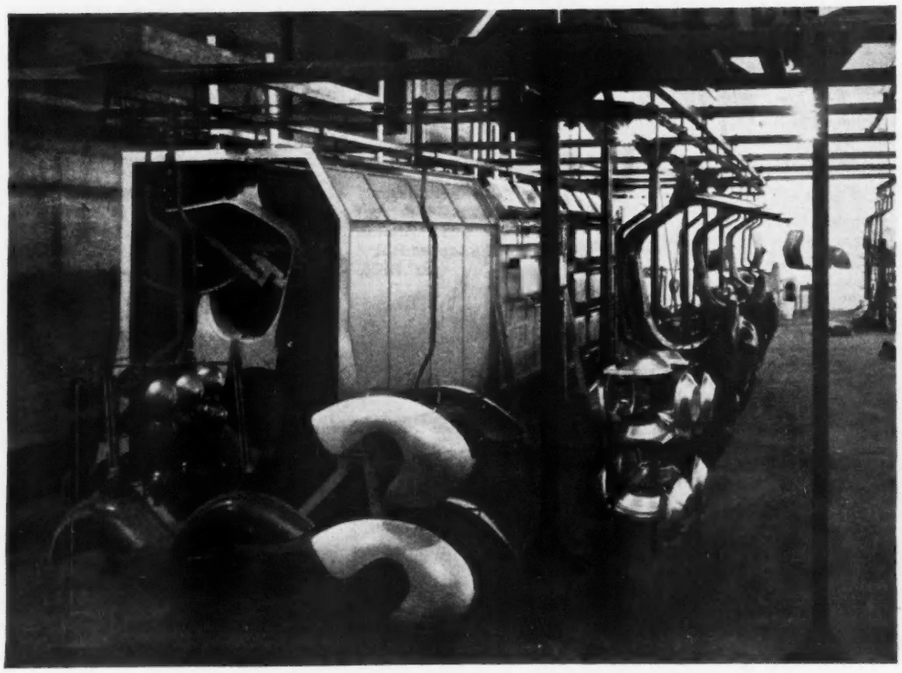


Fig. 3. Gas-fired paint stoving oven for Vespa parts including chassis, lamp housings, steering columns with mudguards, engine wings and fan cowlings, installed at Douglas Engineering (Kingswood) Ltd.

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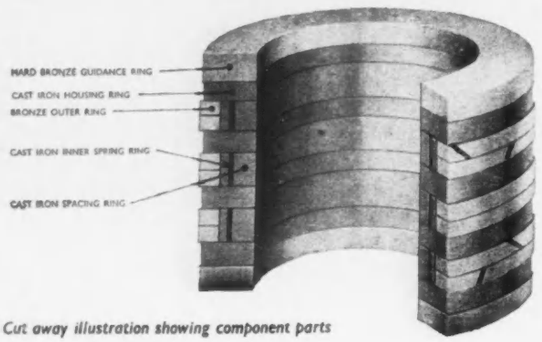

Cut away illustration showing component parts

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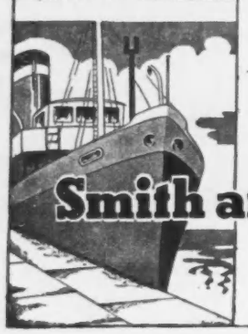

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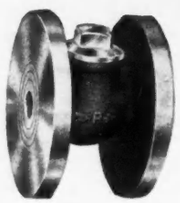

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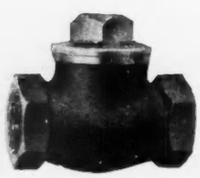

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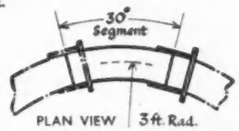
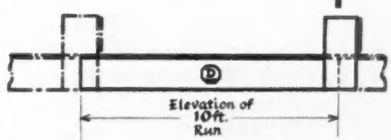
Curved sections are available in 3ft. radius 30° segments, and 6ft. radius 15° segments.





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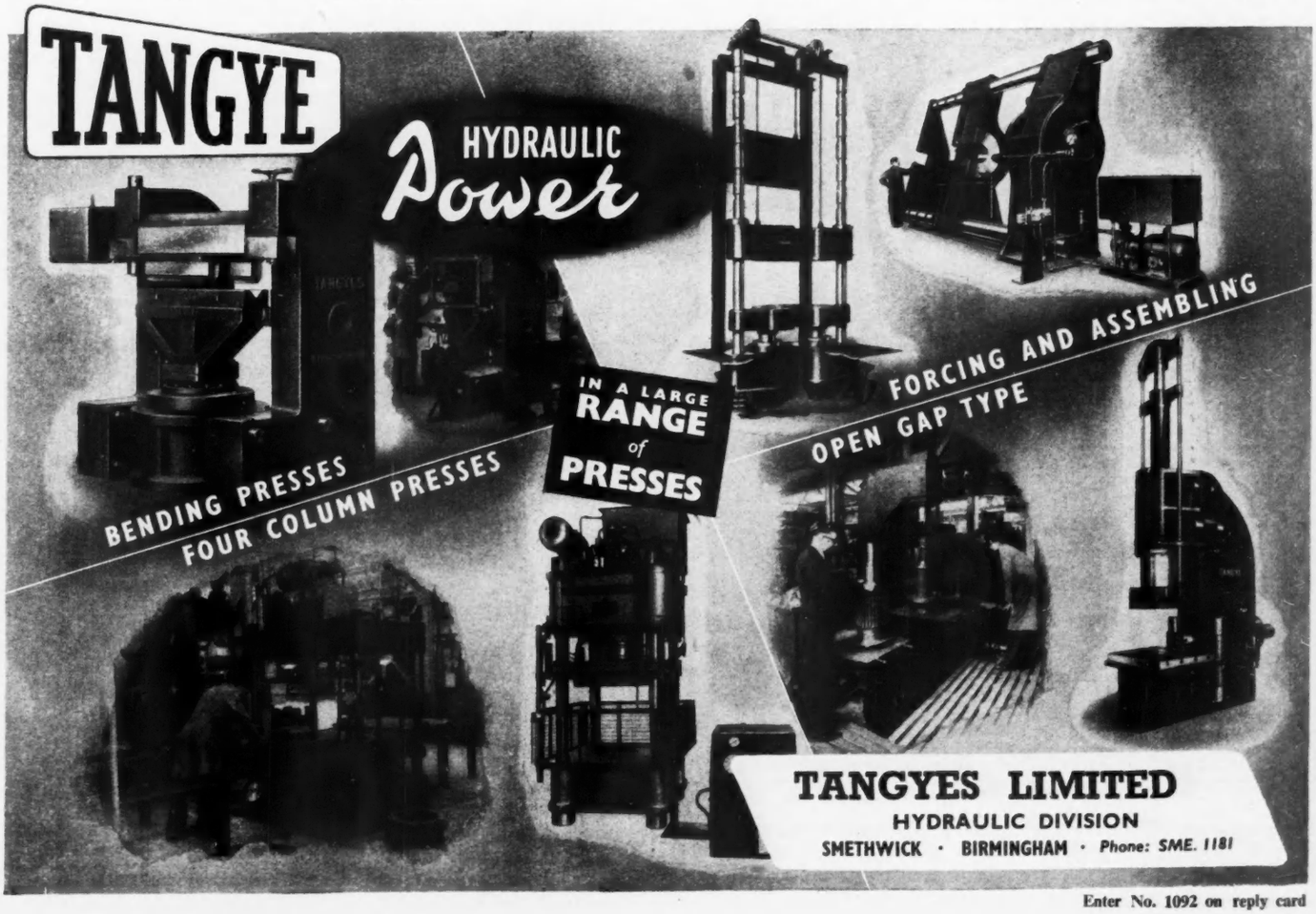

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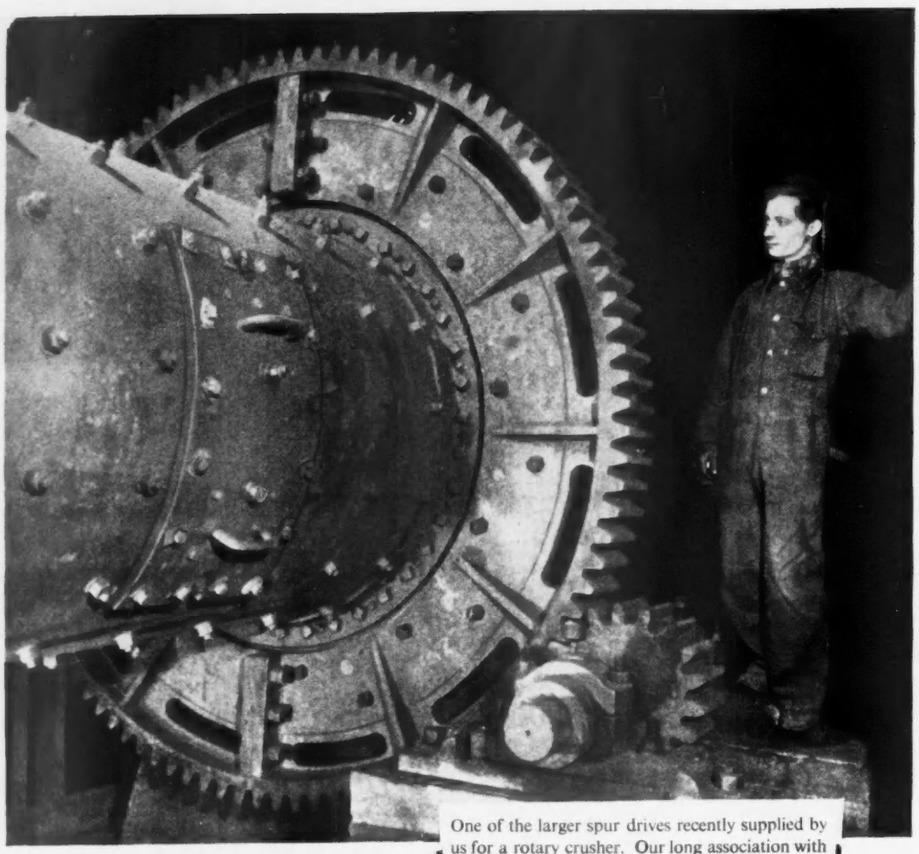

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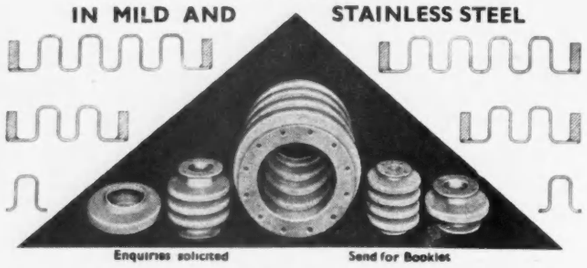

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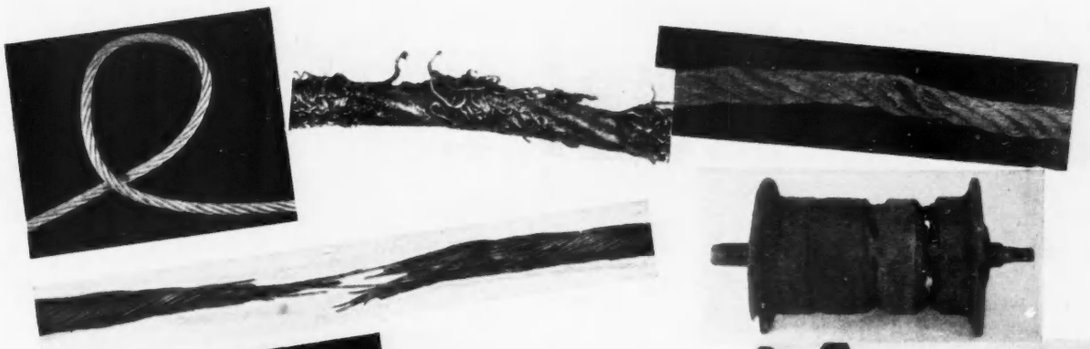

IF YOU KNOW THE ROPES

These photographs show some typical instances of damage to ropes and associated equipment caused by mishandling, wrong fitting or neglect. In each case serious damage was caused to the Wire Rope and considerable expense was involved in replacement and loss of output.

To prevent such occurrences and to help you to get long, safe life from your wire ropes we have compiled and published a series of papers *"Give Your Ropes a Chance"* which contains much useful and interesting information. We will be pleased to send you copies on request.

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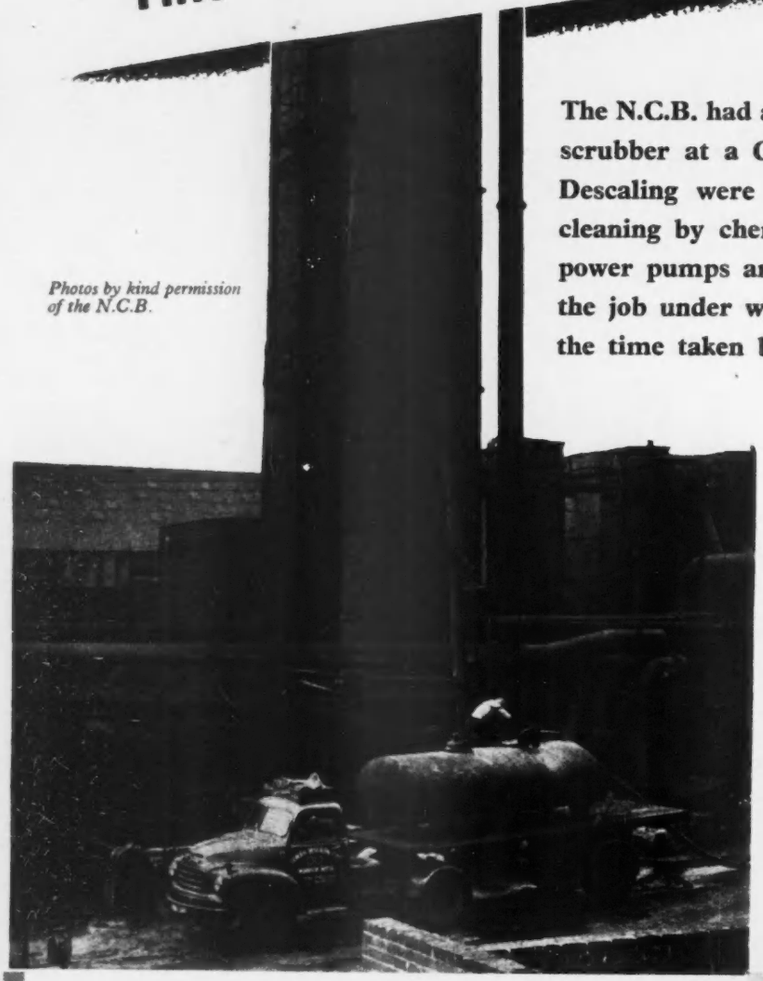
The N.C.B. had a problem. . . how to clean this 100ft. benzole scrubber at a Carbonisation Plant in a hurry. General Descaling were called in and they immediately advised cleaning by chemical means. Experienced men and the power pumps and other equipment were soon on site and the job under way - and completed in only one tenth of the time taken by previous methods.



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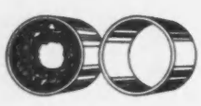

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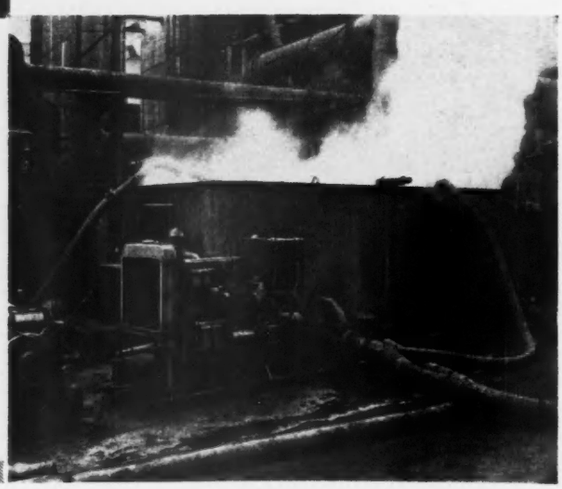
Tel. Worksop 3211/3.



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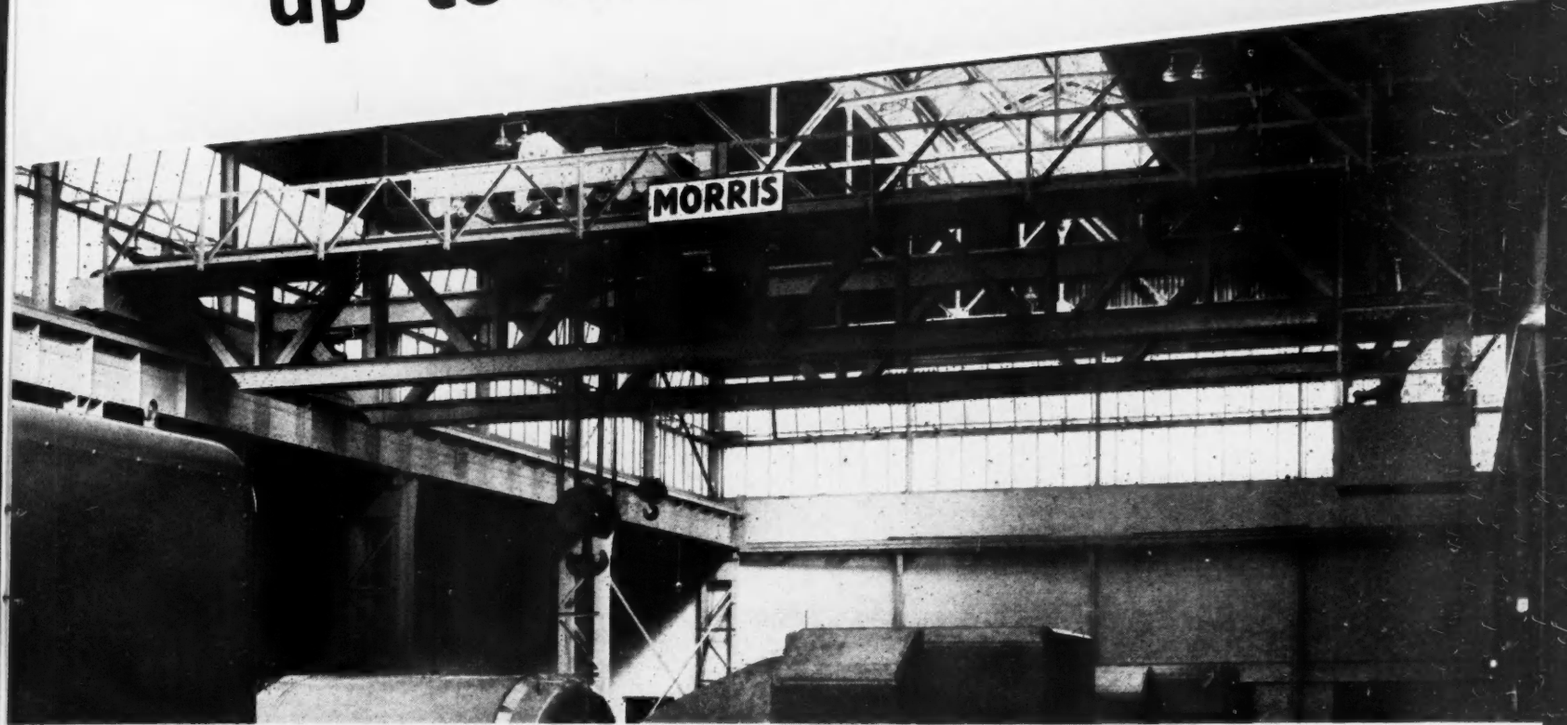

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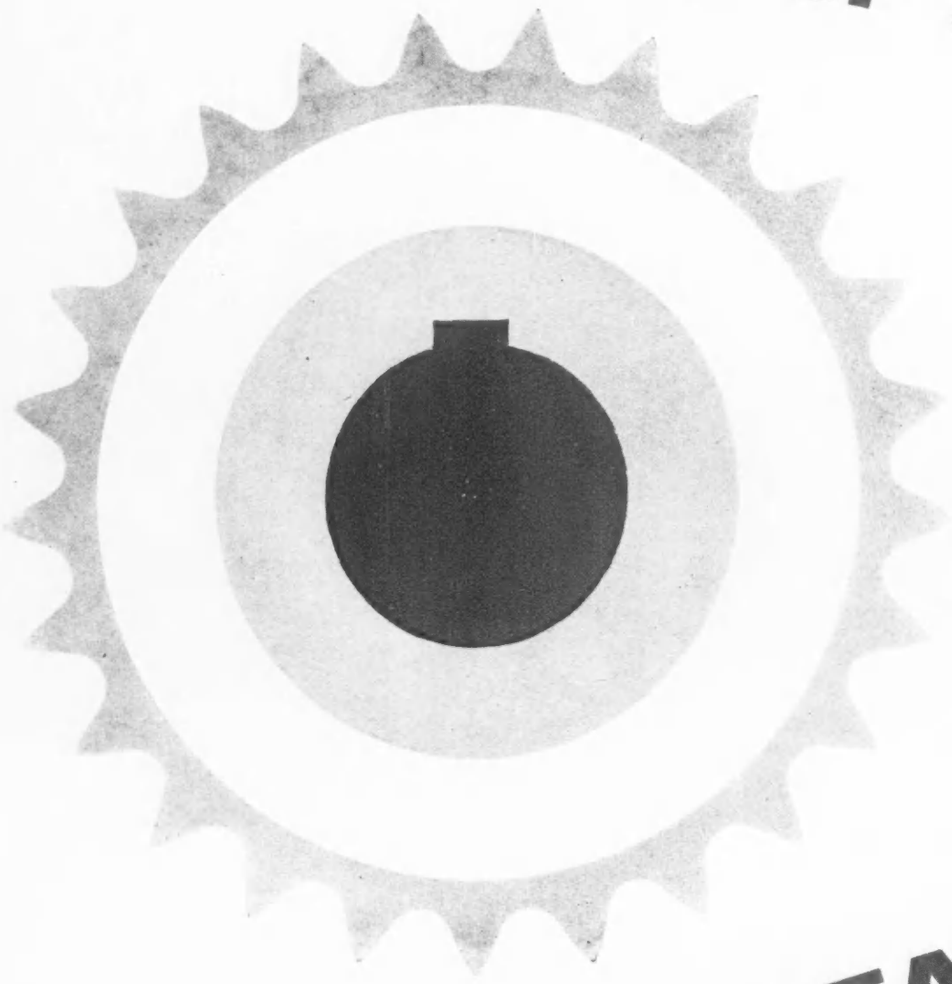

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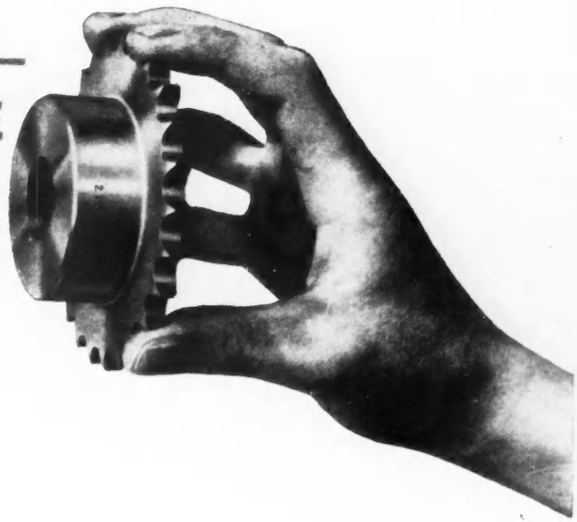
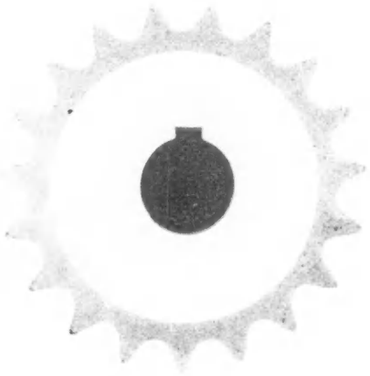


PINIONS



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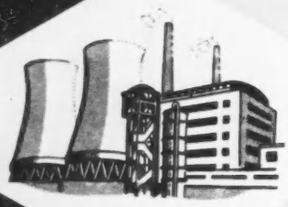
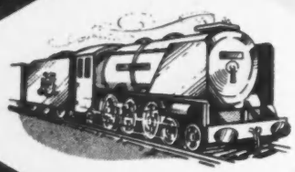
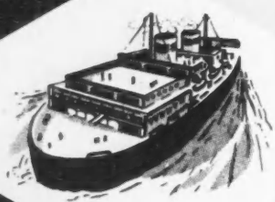
INTERNAL WATER TREATMENT FOR BOILERS







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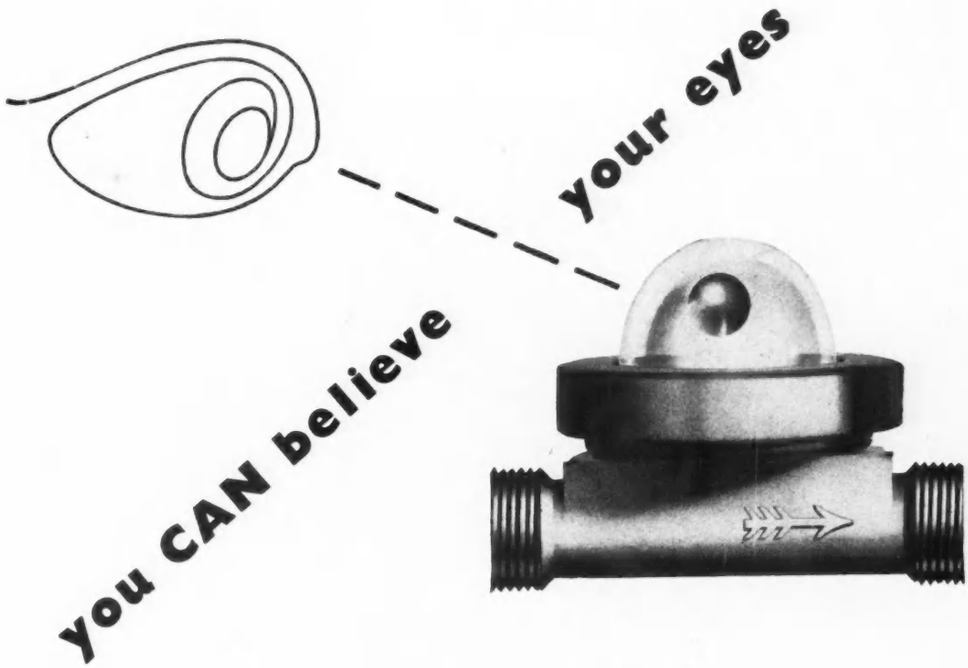

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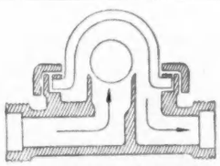
Where circulating water systems are concerned, for radiators, condensers, liquid vats, oil coolers, radio transmitting equipment and the like, a 'SHOFLO' Indicator is the perfect answer when you've got to tell *at first sight* whether the coolant is flowing or not.



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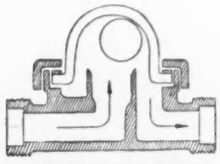
A whirling ball under the toughened glass dome indicates passage of clear or translucent liquids at flows as low as 4 g.p.h., pressures up to 100 p.s.i. Standard casing is aluminium bronze for ½" sizes, gunmetal for 1½" sizes; other metals for alkaline or acidic fluids.



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Available in two sizes: Nominal ½" and 1½" bores for flows up to 2,000 g.p.h. ½" size also made with right angle inlet and outlet.

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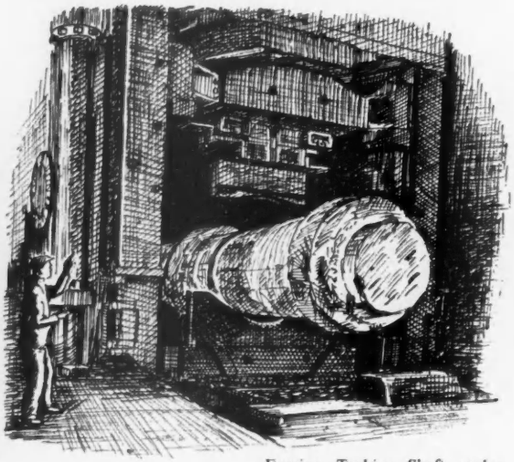
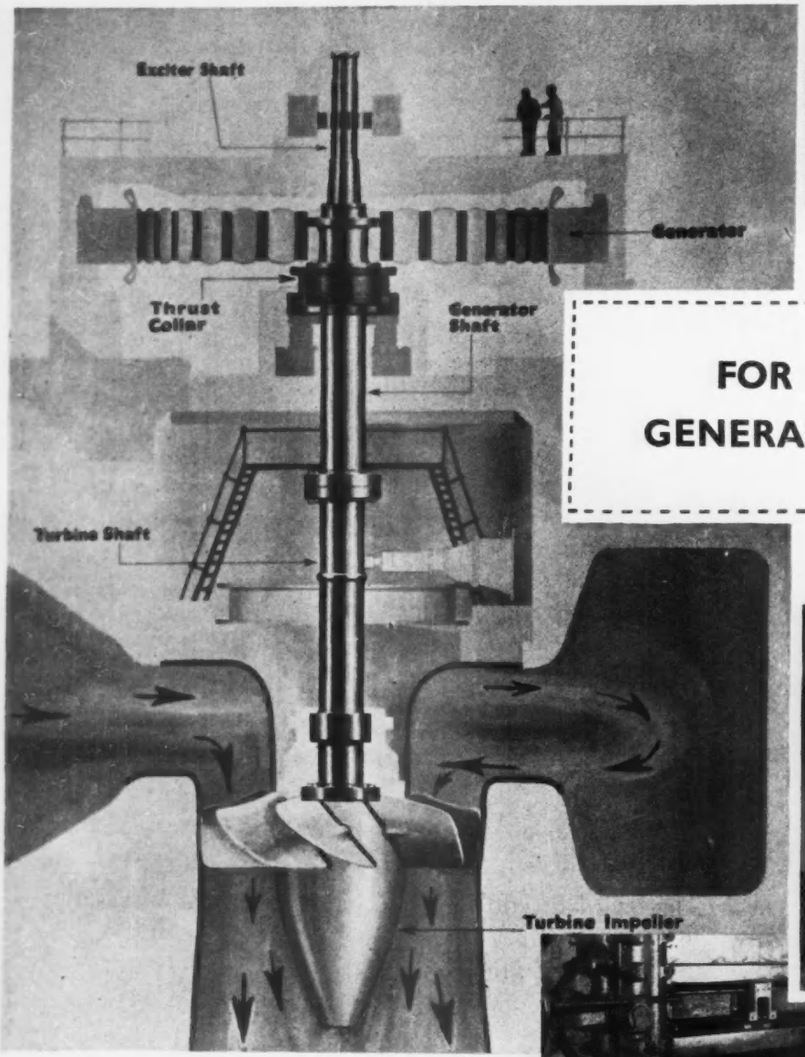
Steel Forgings...



Forging Turbine Shaft under 7,000 ton Electro-Hydraulic Press.



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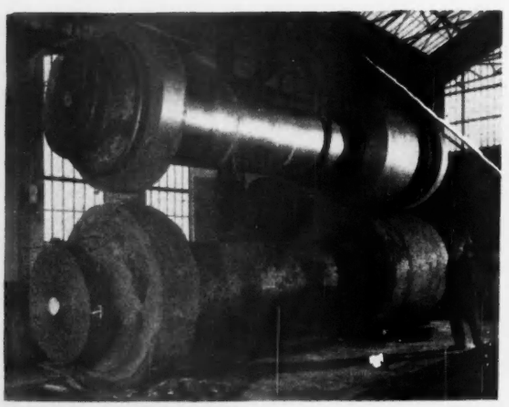
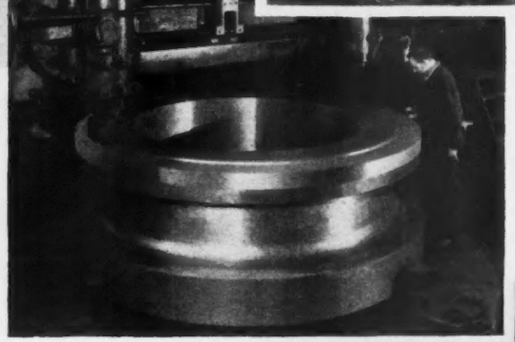
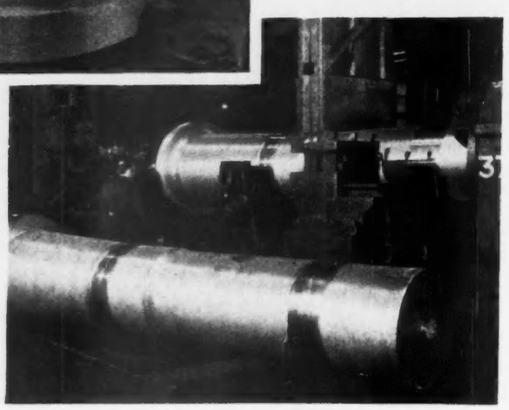


Rough machined and black forged steel Turbine Shafts, 22' 11" long.



Machining forged steel Thrust Collar, weight 18½ tons.

Forged steel Exciter Shafts, each weighing 8½ tons.



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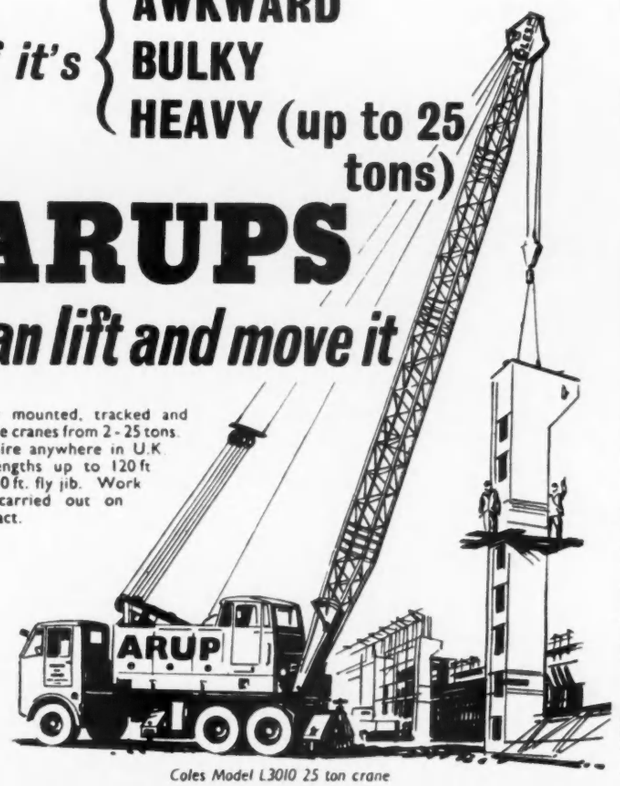

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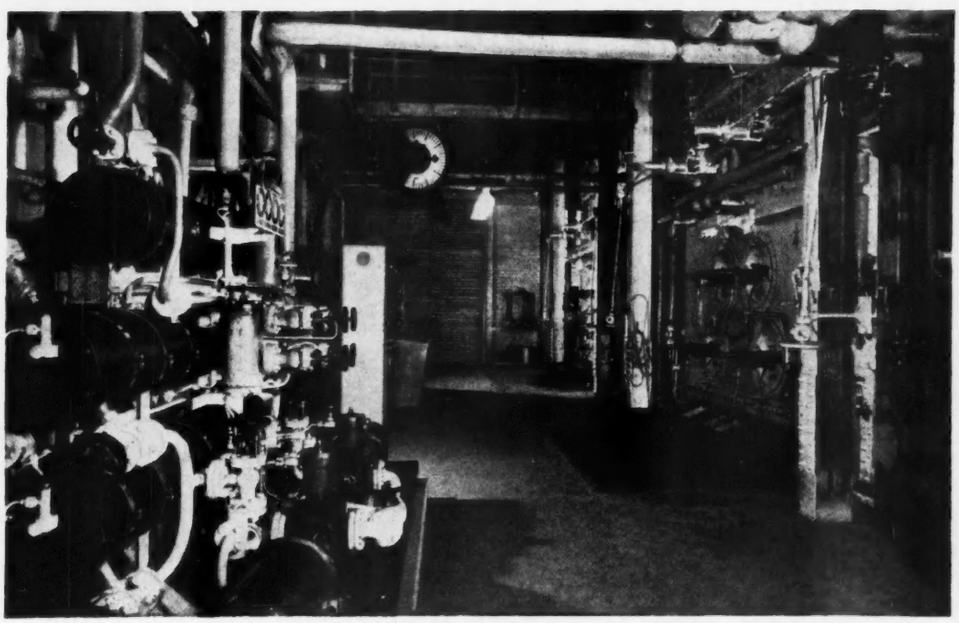

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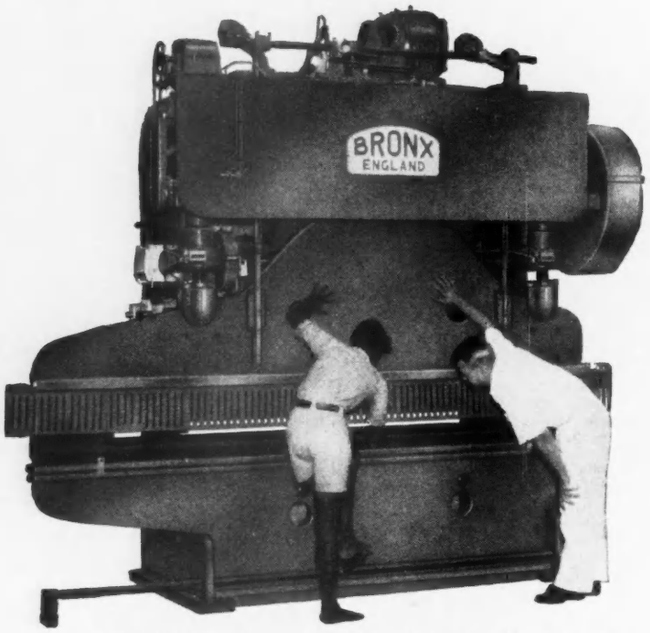

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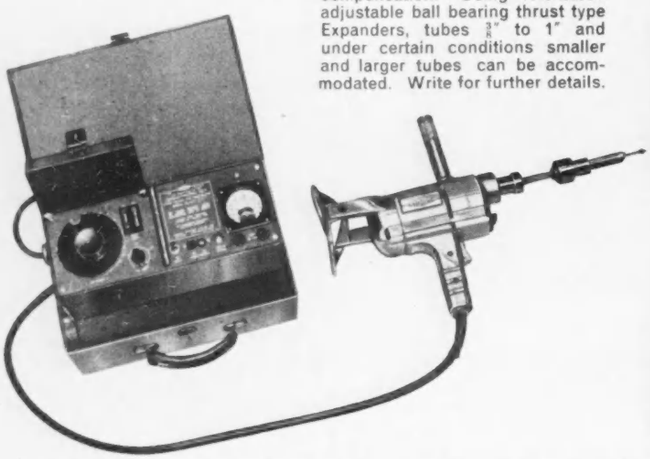

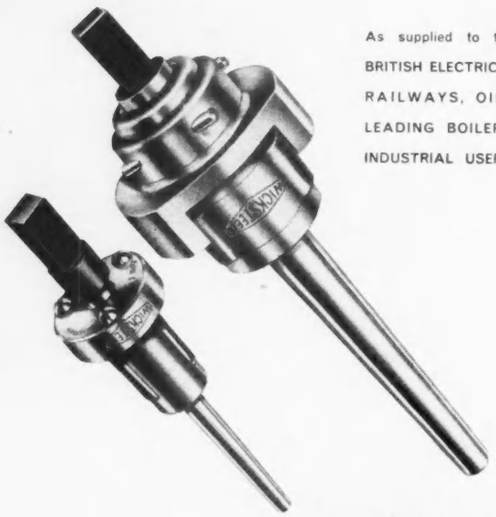

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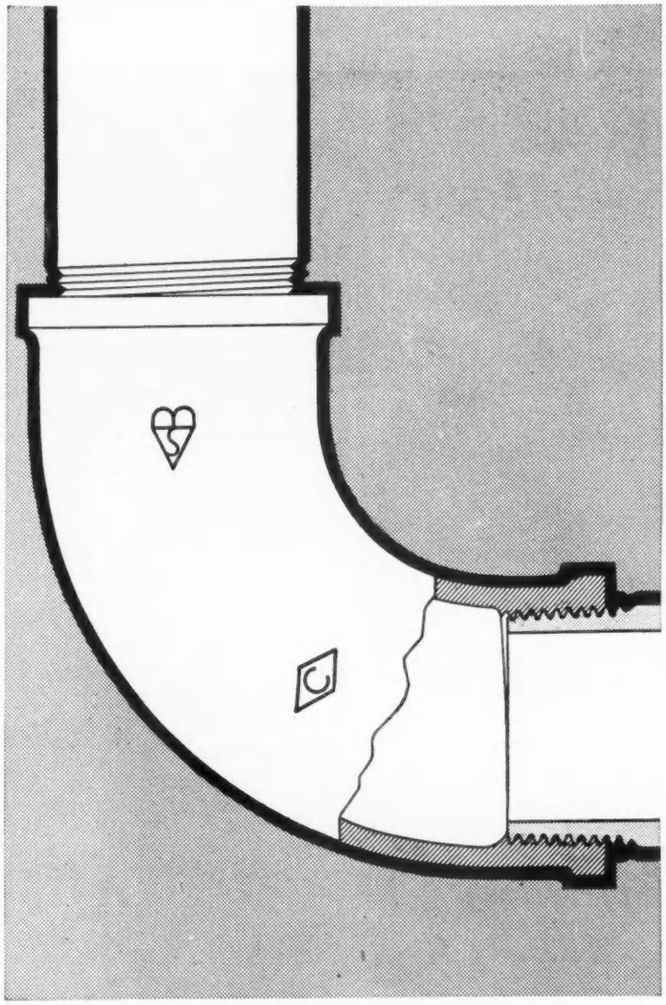

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Because they are made with the taper threads of Crane Malleable Iron Pipe Fittings. All Crane Pipe Fittings made to British Standard 143 have taper threads, which not only make a more efficient, tighter joint, *but eliminate the need for hemp packing*. Hence, a cleaner finish and better all-round appearance.

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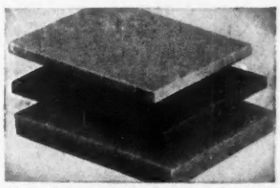

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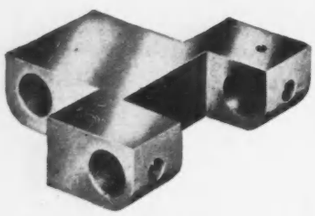

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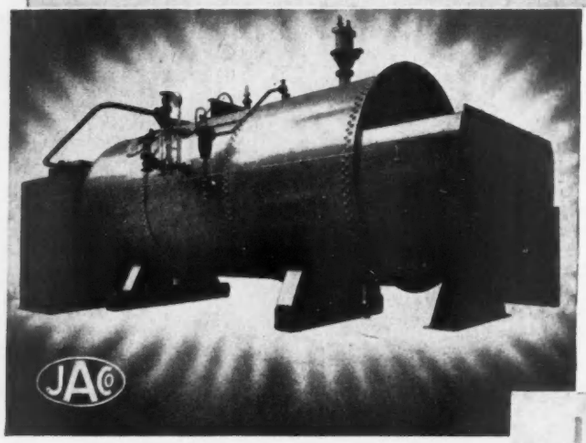

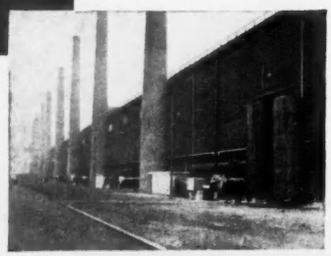

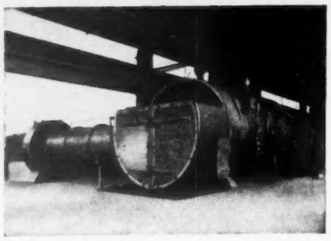

The Joseph Adamson Waste Heat Boiler is designed to make efficient use of the waste gases leaving open-hearth furnaces, reheating furnaces, soaking pits, gas retorts, etc.

The straight-through fire tubes have a high ratio of length to bore, giving about 90% tube efficiency and providing a large area of heating surface in a comparatively small space. Brickwork setting is not required and air infiltration is thus avoided.

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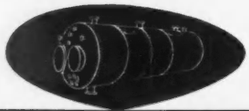

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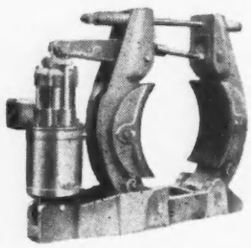

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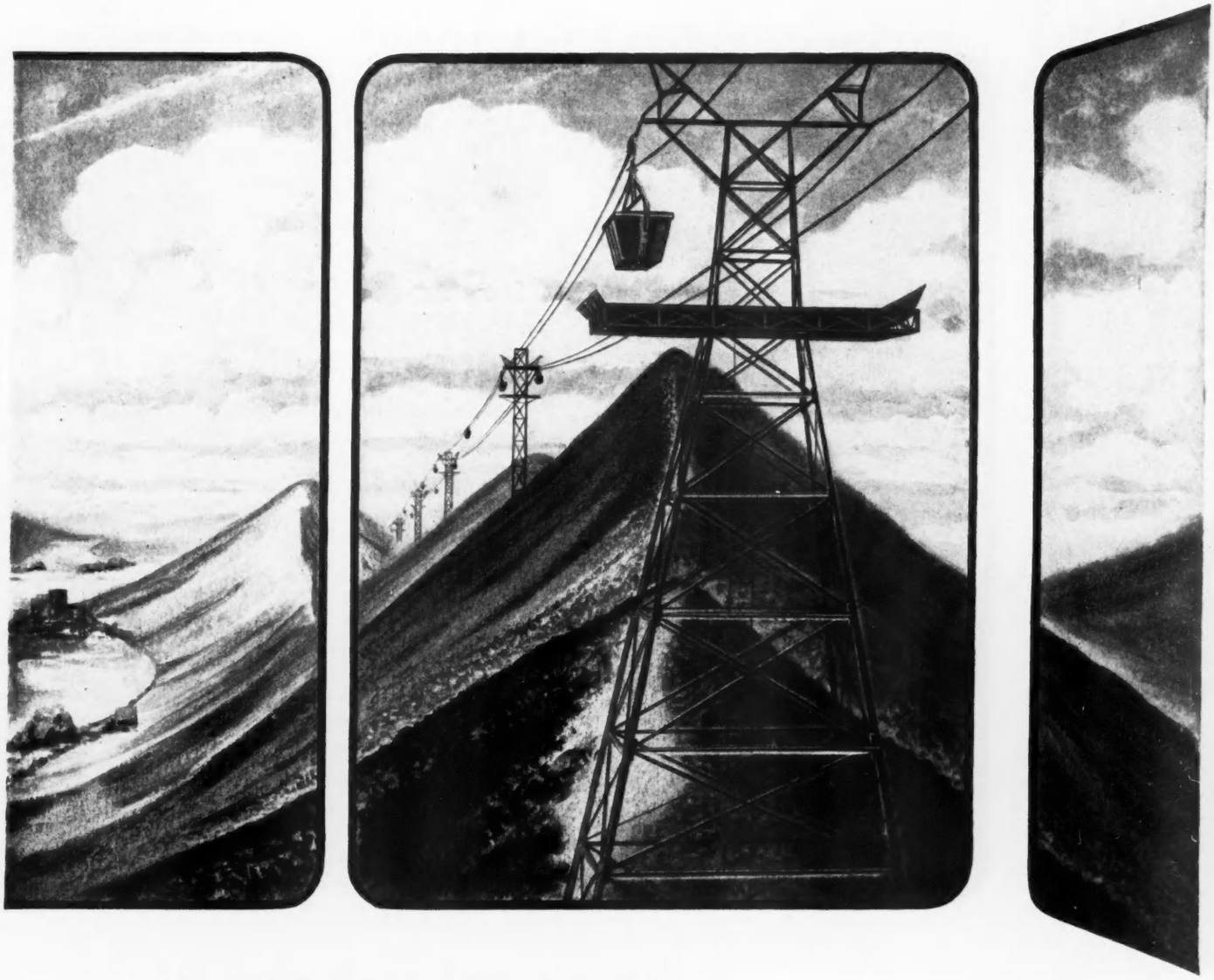

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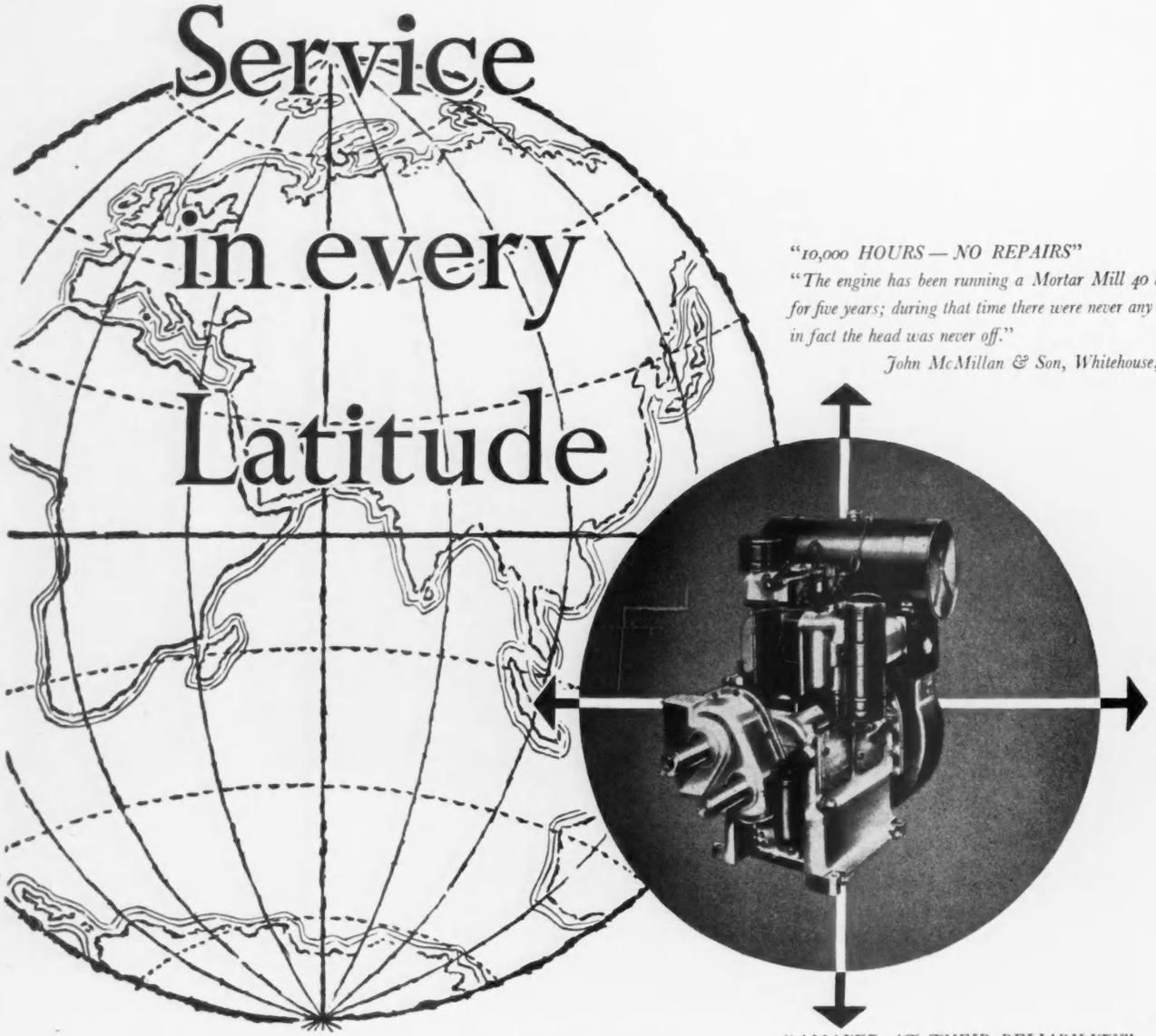

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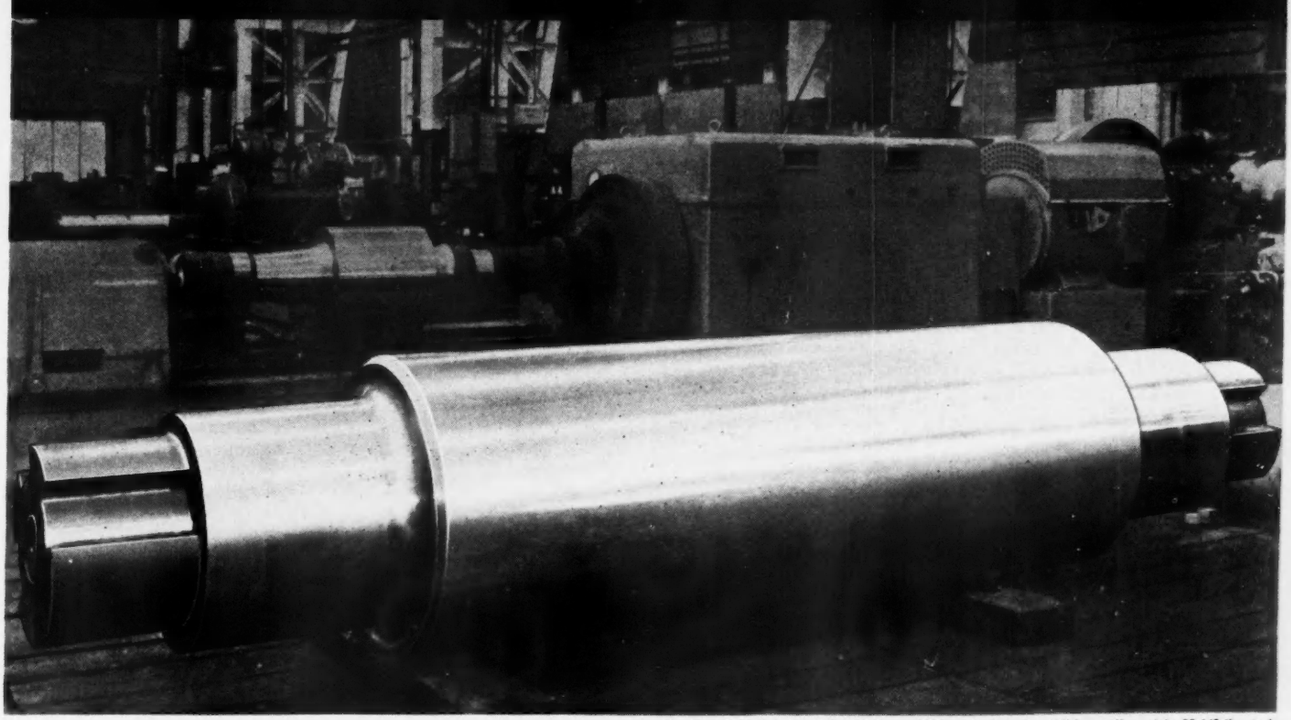

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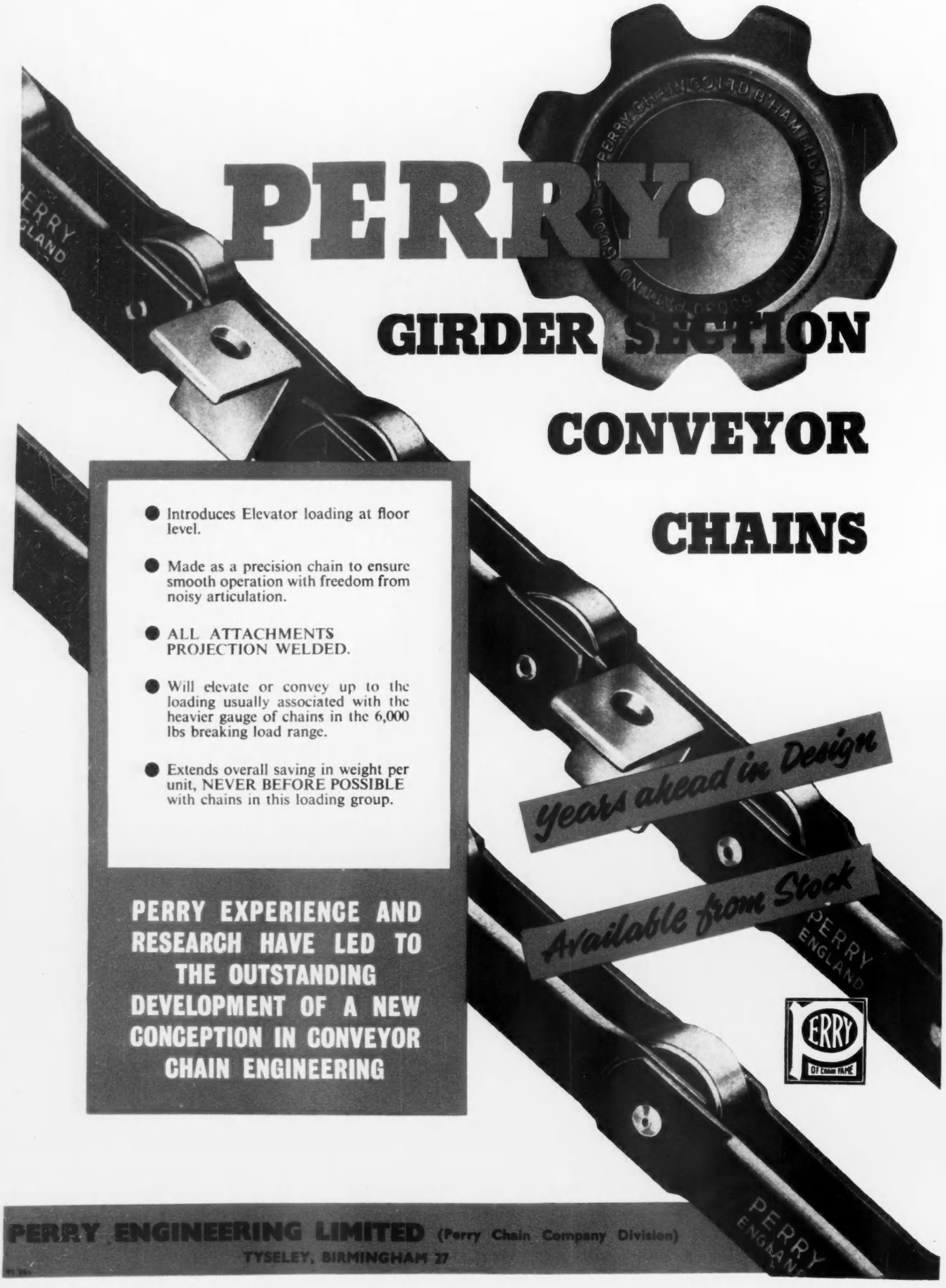

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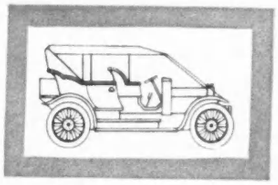

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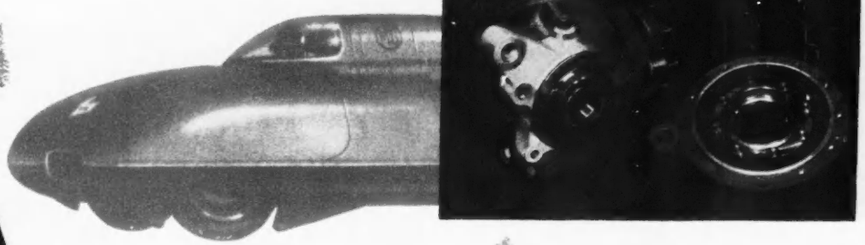

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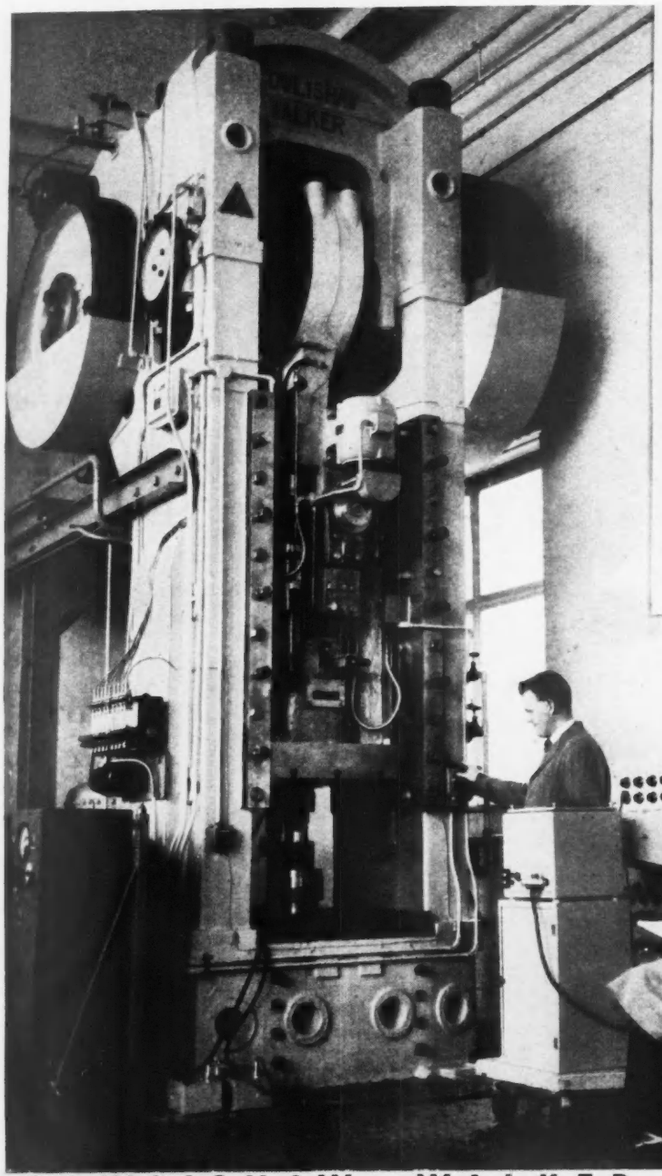

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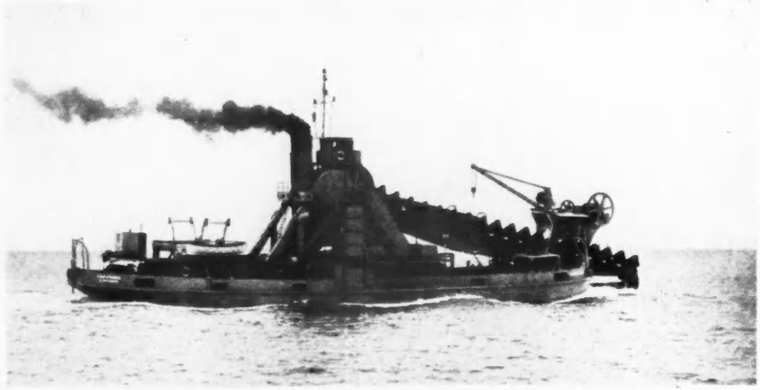

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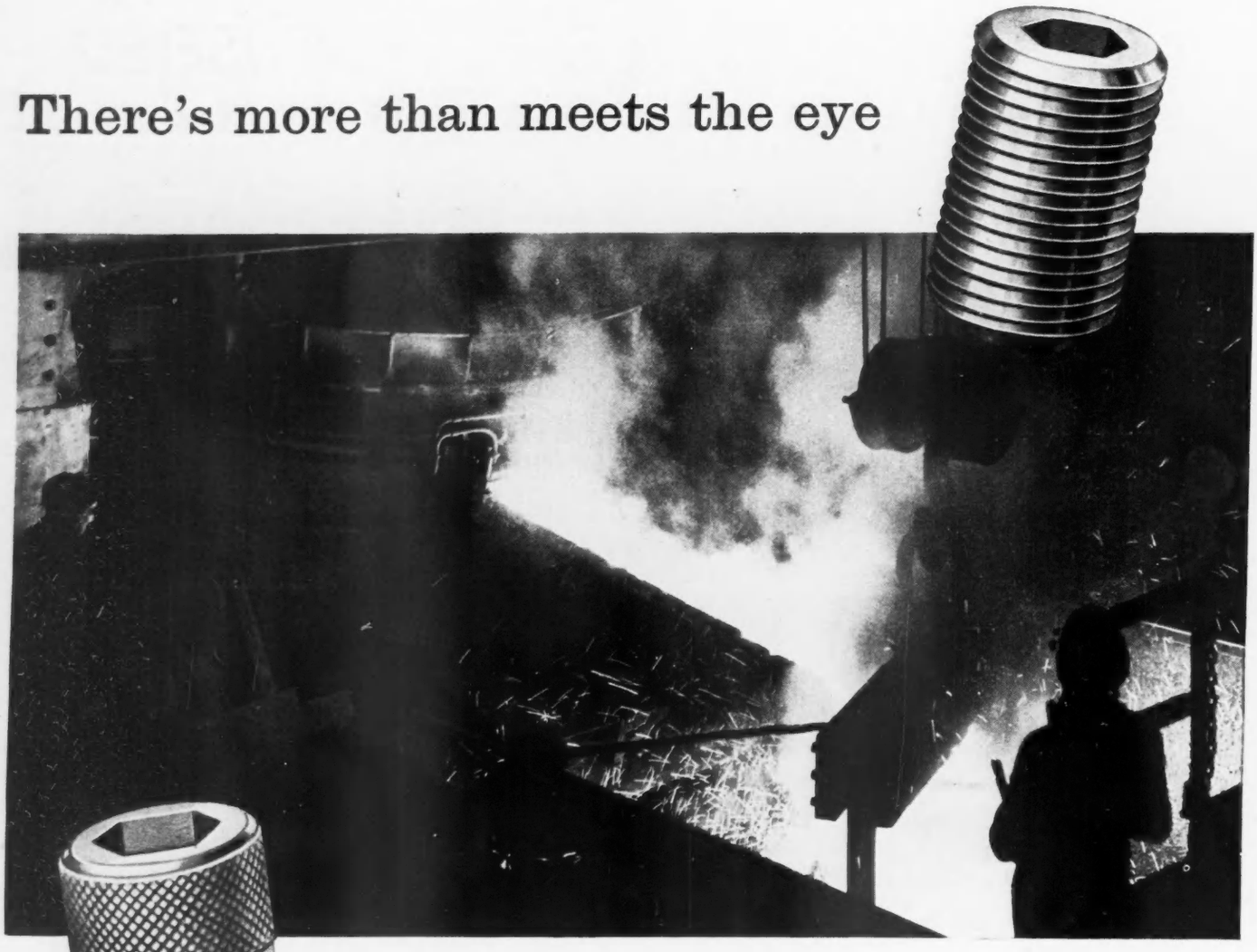

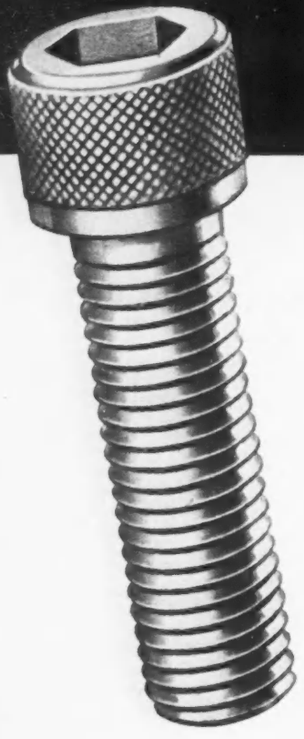

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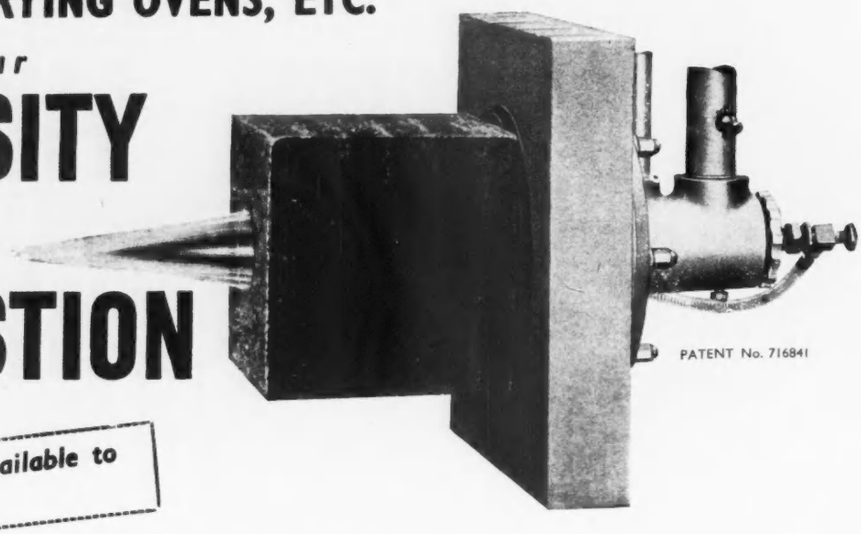

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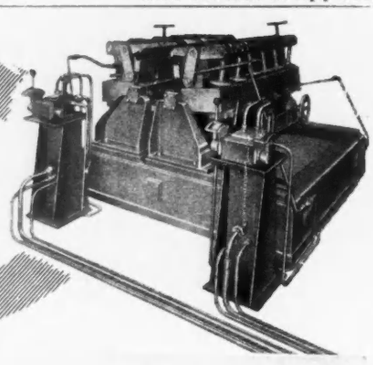
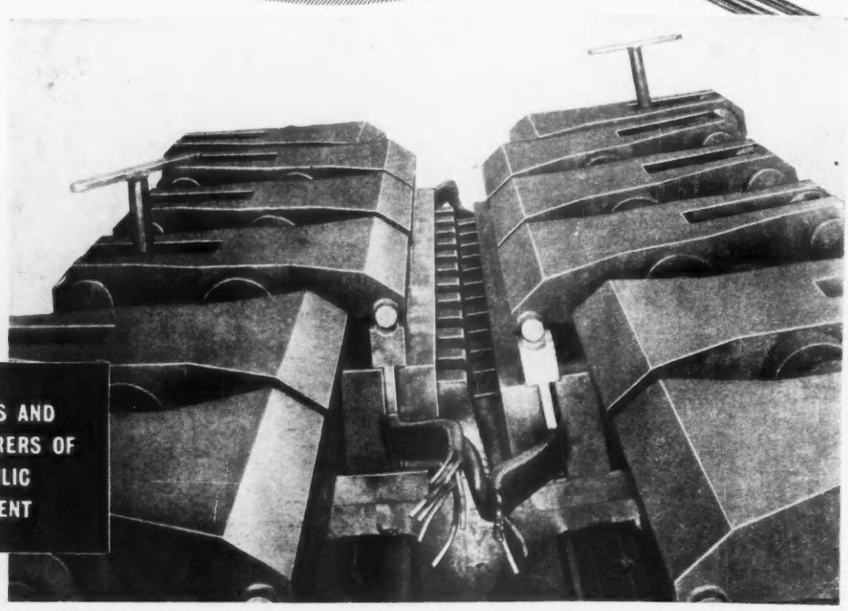


Specially developed for the electrical industry, the press illustrated is one example of the variety of machines we supply to customers' requirements.



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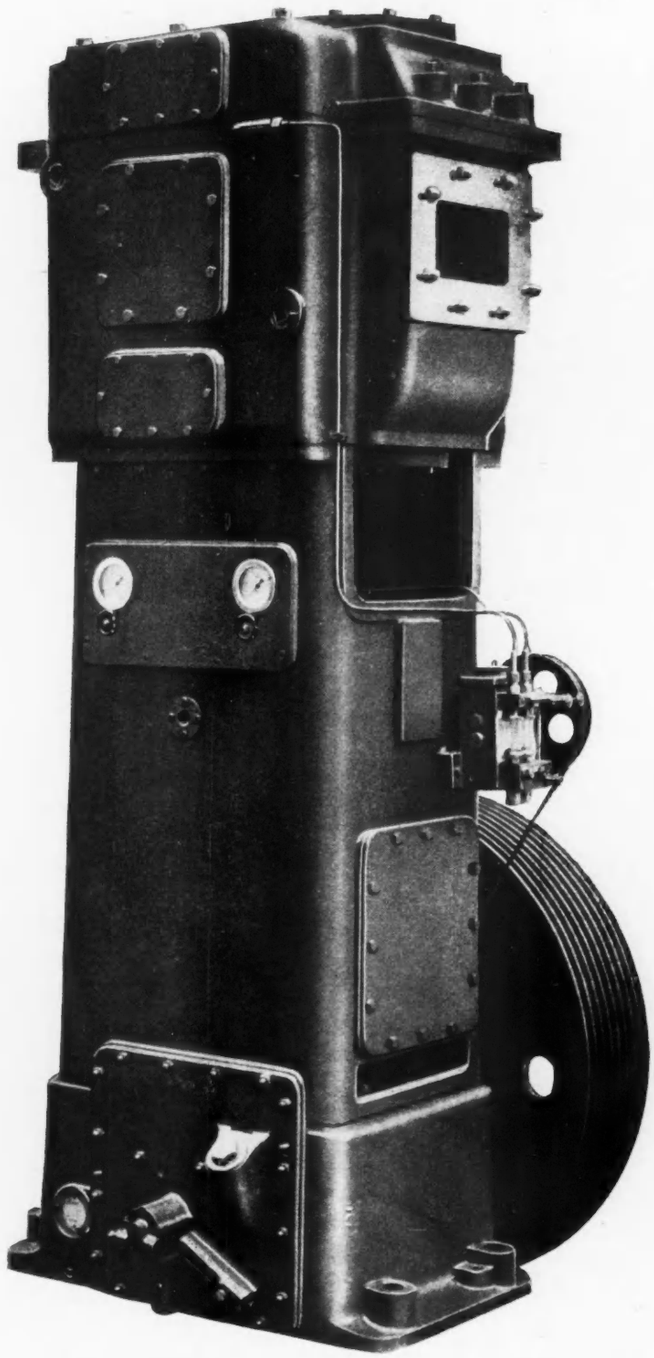

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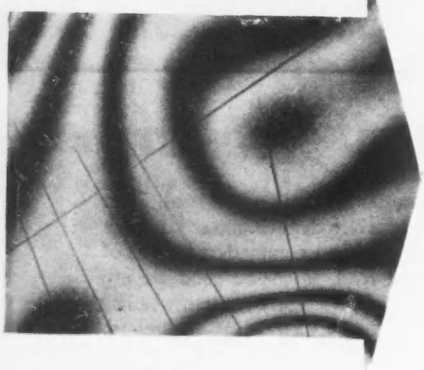

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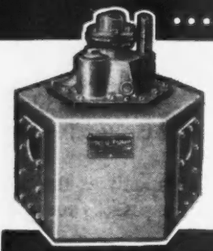

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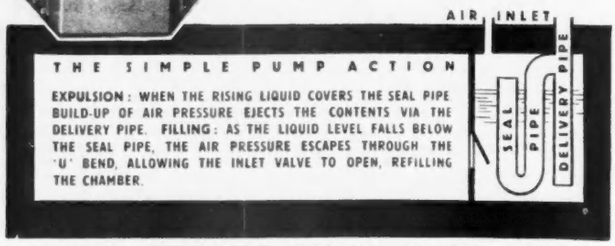
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EXPULSION: WHEN THE RISING LIQUID COVERS THE SEAL PIPE BUILD-UP OF AIR PRESSURE EJECTS THE CONTENTS VIA THE DELIVERY PIPE. FILLING: AS THE LIQUID LEVEL FALLS BELOW THE SEAL PIPE, THE AIR PRESSURE ESCAPES THROUGH THE 'U' BEND, ALLOWING THE INLET VALVE TO OPEN, REFILLING THE CHAMBER.
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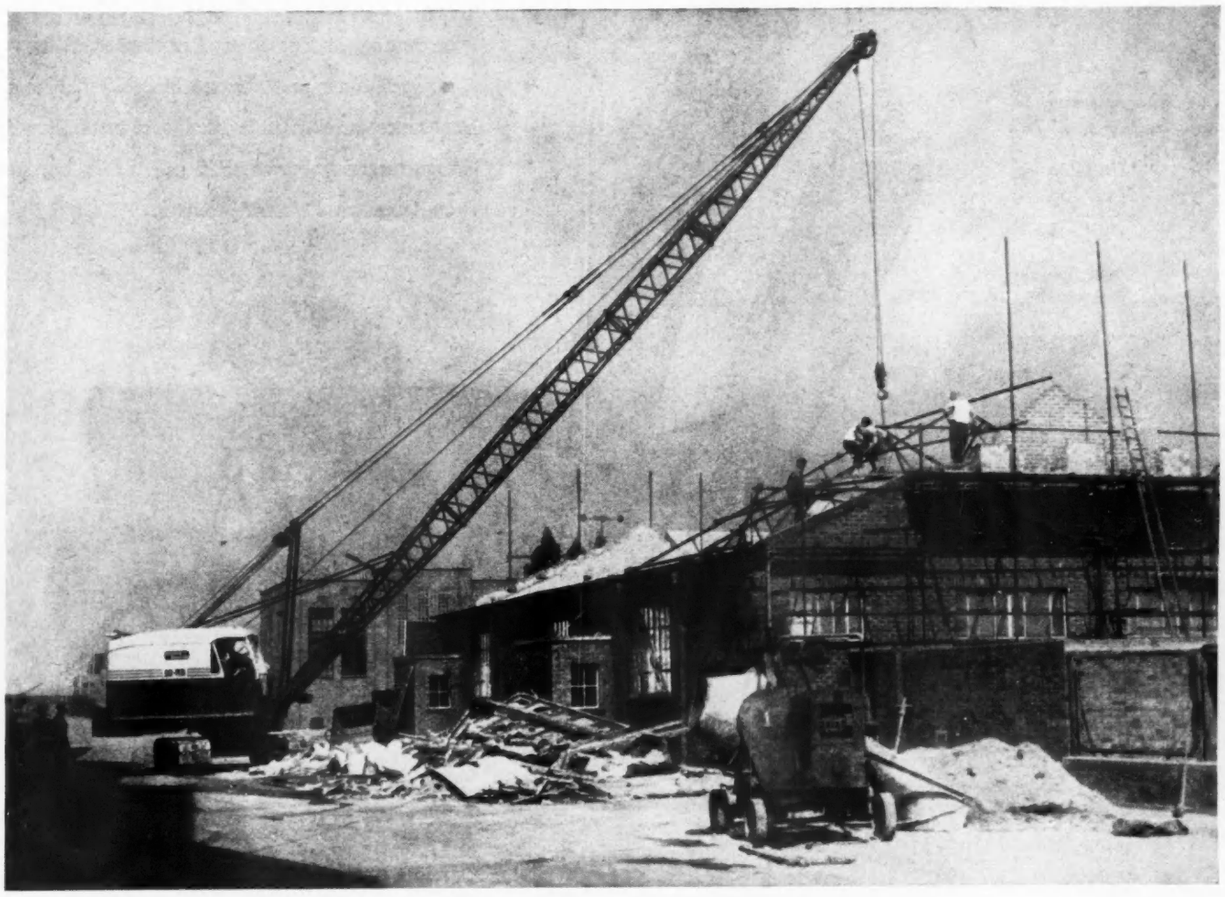

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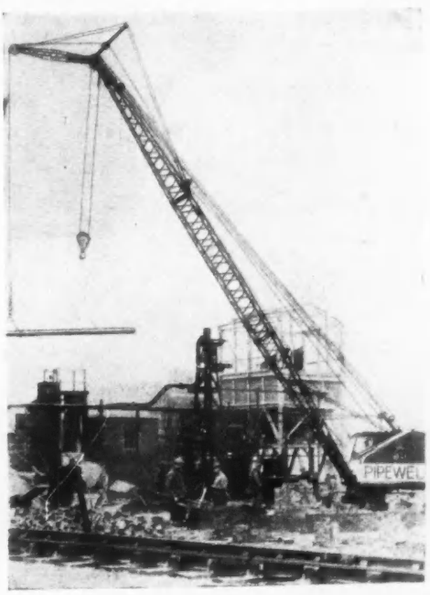

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Araldite epoxy resins are used

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AP 464

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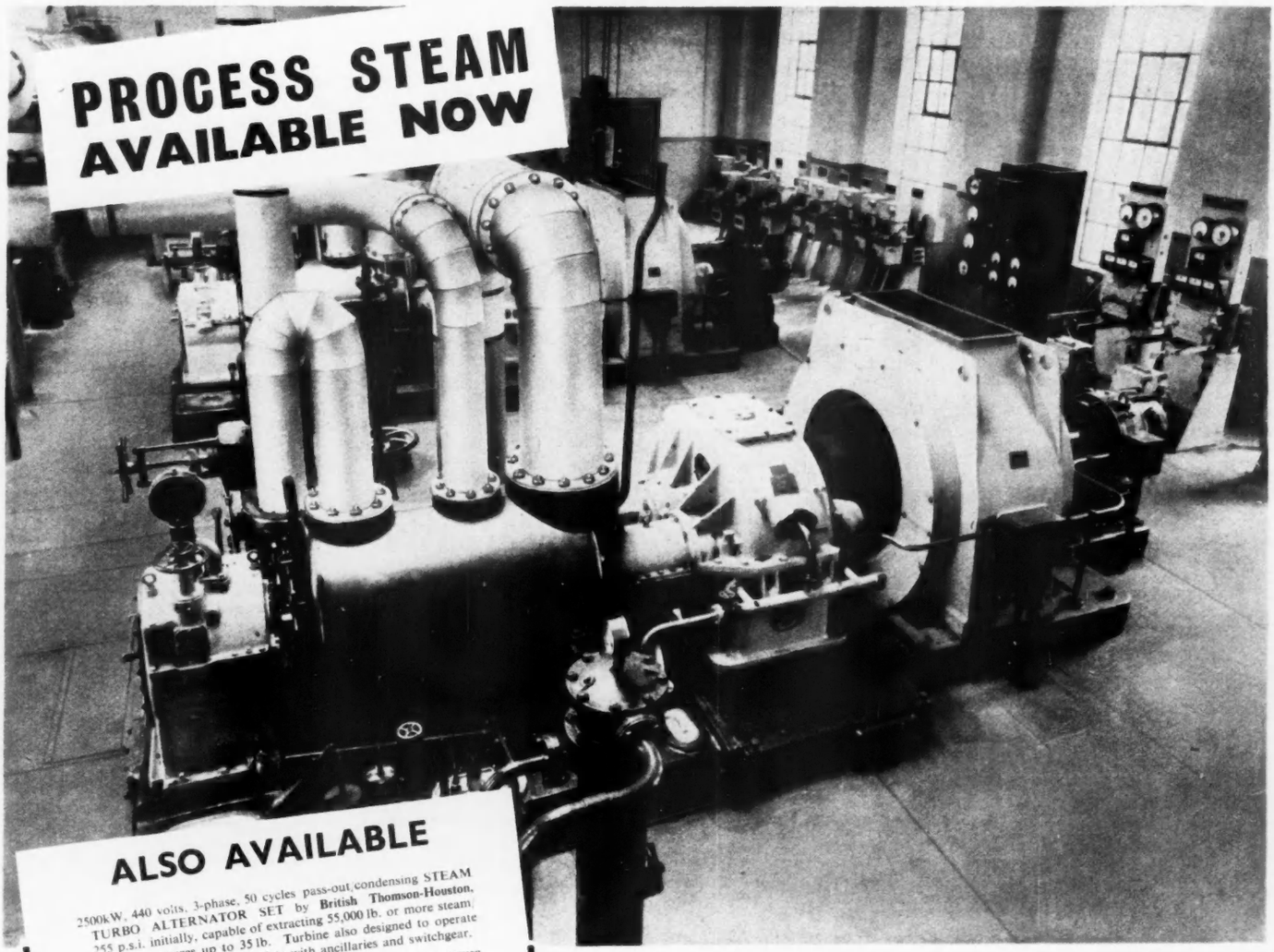

TWO 1000 kW back pressure type STEAM TURBO ALTERNATOR SETS incorporating turbines by **Belliss & Morcom,** designed for a steam pressure of 195 lb./sq. in. and suitable for exhausting against 15/20 lb. back pressure. The turbines direct coupled through gearbox by **David Brown,** ratio 4·5 : 1, to alternators by **Harland Engineering Co.,** 1250 kVA, 0·8 p.f., wound for 3·3 kV, 3 phase, 50 cycles, star connected 1000 r.p.m. with direct coupled exciter. Complete with control gear and automatic voltage regulator.

ALSO AVAILABLE

2500kW, 440 volts, 3-phase, 50 cycles pass-out condensing STEAM TURBO ALTERNATOR SET by **British Thomson-Houston,** 255 p.s.i. initially, capable of extracting 55,000 lb. or more steam/hour at pressures up to 35 lb. Turbine also designed to operate fully condensing and is complete with ancillaries and switchgear.

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750kW, 400 volts, 3-phase, 50 cycles back pressure type STEAM TURBO ALTERNATOR SET by **Metropolitan-Vickers,** incorporating turbine designed to work with steam at 485 p.s.i., 550 deg Fah. temperature, exhausting to back pressures between 25 lb. and 60 lb. Direct coupled to alternator, complete with switchgear.

NEW 500kW geared back pressure type STEAM TURBO ALTERNATOR SET by **Metropolitan-Vickers,** incorporating turbine designed to work with steam at 510 p.s.i. initially, 800 deg. Fah temperature, exhausting against 170/185 p.s.i. back pressure Direct coupled through gearbox to alternator wound for 400/440 volts, 3-phase, 50 cycles supply, 1500 r.p.m., with exciter and switchgear.

500kW back pressure type STEAM TURBO ALTERNATOR SET by **British Thomson-Houston,** incorporating turbine designed to operate with steam at 300 p.s.i., 150 deg. Fah. superheat, exhausting against 60 lb. back pressure. Direct coupled at 3000 r.p.m. to alternator wound for 400 volts, 3-phase, 50 cycles supply, with exciter and switchgear.

300kW, 375kVA, 400/440 volts, 3-phase, 50 cycles, 4-wire STEAM ENGINE DRIVEN ALTERNATOR SET incorporating compound engine by **Belliss & Morcom,** with h.p. cylinder 19in. bore, l.p. cylinder 25½in. bore by 12in. stroke. Engine arranged to work with steam at 140 p.s.i., 450 deg. Fah. temperature exhausting to back pressures up to 25 lb. Direct coupled to alternator by **English Electric Co.,** with exciter and switchgear.

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AUTOCLAVES & VULCANISERS
with Pat. "Quicklock" door.
CHEMICAL PLANT, CREOSOTING PLANT, VACUUM DRYING & IMPREGNATING PLANT, HYDRAULIC PRESSWORK.

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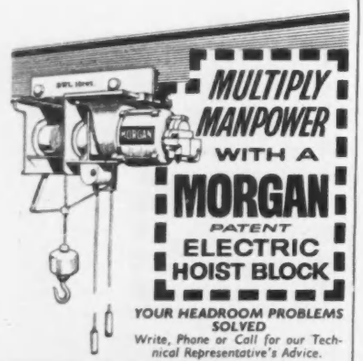
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YOUR HEADROOM PROBLEMS SOLVED
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London Office: 421, Grand Buildings, Trafalgar Square, W.C.2. 'Phone: WHitehall 5643 and 7963

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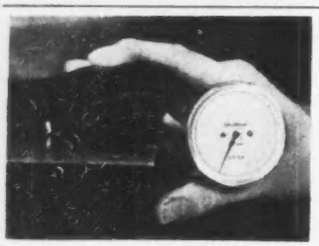
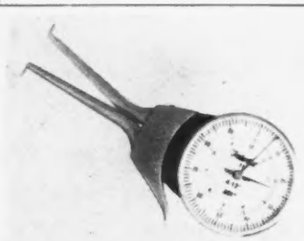

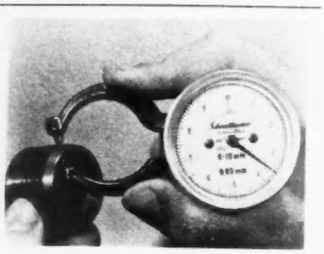
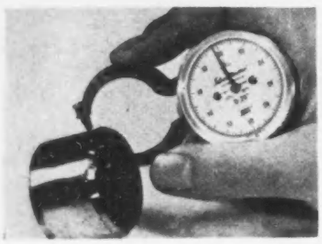
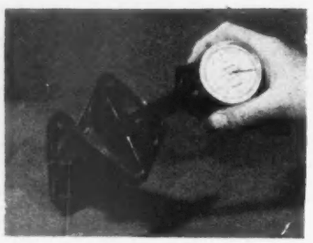

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170 standard models and, in addition, special models made to order for all sorts of measuring purposes.

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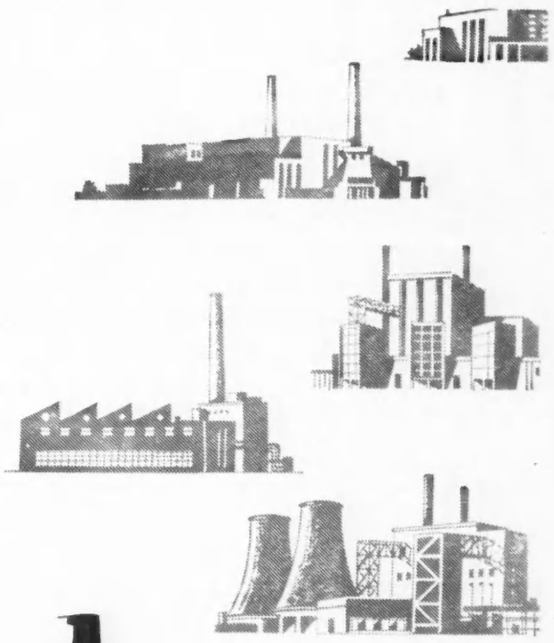

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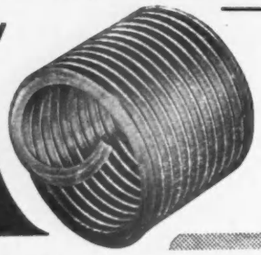

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We also make Stainless and Bronze for other applications.

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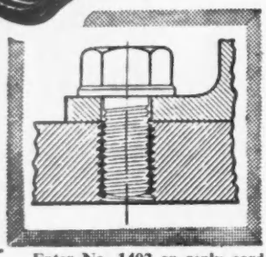
Tel: Combe Down 2355-8 BATH, SOMERSET Grams: Circle, Bath
Specialists in JET ENGINE LABYRINTHS, CIRCLIPS, SPRING WASHERS, SPRINGS, etc.



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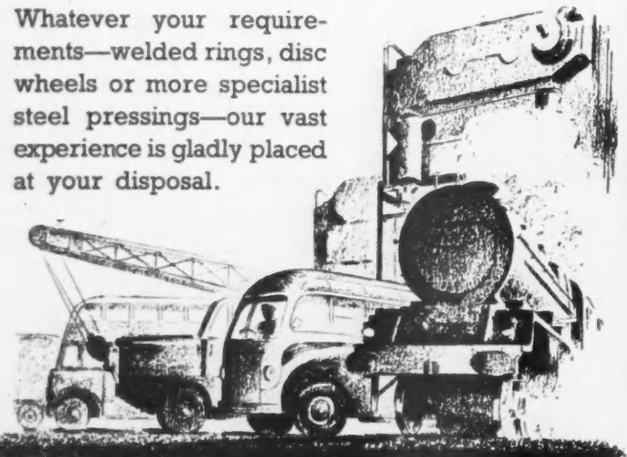
come the needs
of Industry . . .

In almost every branch of Industry the pressings from Steel Stampings Ltd., can be found satisfying a vital need.

Whatever your requirements—welded rings, disc wheels or more specialist steel pressings—our vast experience is gladly placed at your disposal.



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GALVANIZING
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We can provide plant heated by gas, electricity, coal or oil and we will give you practical advice on any of your galvanizing problems.

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Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

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(b) HEAD of the BUILDING DEPARTMENT.

The work extends to H.N.C. standard in both Departments.

Salary scale: £1600 by £50 to £2000 p.a. It is proposed to make an appointment above the minimum of the scale according to qualifications and experience for an initial period of 3 years. Appointment thereafter would be pensionable or, if desired, could continue on contract at same salary plus a gratuity of 20 per cent for each period of 3 months' satisfactory service, payable at end of contract.

Free passages on appointment, leave and completion of service. Housing assistance.

Further information obtainable from Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2, to whom applications (6 copies) giving age, qualifications, experience and names of 3 referees should be sent by 8th January, 1959. E8134

READING TECHNICAL COLLEGE

LECTURERS

Applications are invited for the following posts, to be filled as soon as possible:

1. SENIOR LECTURER IN MANAGEMENT STUDIES. (Salary: £1550 by £50 to £1750).
2. LECTURER IN PRODUCTION ENGINEERING (METALLURGY). (Salary: £1370 by £35 to £1550).

For Post 1 applicants should have professional qualification in Engineering and, particularly, in Work Study, good managerial industrial experience and preferably appropriate teaching experience.

For Post 2 the person appointed will be required to take charge of the teaching in Metallurgy up to H.N.C. Endorsement level and to assist in teaching other subjects in Production Engineering field and/or Materials.

Further particulars and forms of application (returnable by 30th December) obtainable from the Principal, Reading Technical College, King's Road, Reading. E8103

BATTERSEA COLLEGE OF TECHNOLOGY, LONDON, S.W.11

(A COLLEGE OF ADVANCED TECHNOLOGY)

LECTURESHIP

Applications are invited from graduates of a British University for a LECTURESHIP in Electrical Engineering. Candidates should have industrial experience and an interest in research. The salary is in accordance with the London Burnham Scale, £1,408 rising to £1,601. Candidates with experience of a similar standing will receive increments above the minimum of the scale. Further particulars from the Clerk to the Governing Body by whom applications should be received as soon as possible. E8100

UNIVERSITY OF MELBOURNE

LECTURER IN INDUSTRIAL ENGINEERING

Applications are invited for the above-mentioned position.

The salary range for a LECTURER is £A.1,500 per annum to £2,100 per annum. Commencing salary will be fixed according to qualifications and experience. Superannuation similar to F.S.S.U. in Great Britain will be provided.

Conditions of appointment can be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 15th January, 1960. E8106

PUBLIC APPOINTMENTS

CITY AND COUNTY OF BRISTOL EDUCATION COMMITTEE

THE TECHNICAL COLLEGE

Principal-Designate: E. POOLE, B.Sc. (Eng.), M.I.Mech.E., M.I.Prod.E.

APPOINTMENTS

As from 1st September, 1960, the above College is being formed by separation of appropriate level work from the College of Technology which becomes a College of Advanced Technology. Appointments to the staff are being made by transfer from existing staff and by new appointments. The Governors now invite applications for the following new posts to take effect from as soon as possible after 1st January, 1960. Applicants should be graduates, or equivalent, with teaching and some administrative experience.

1. HEAD OF DEPARTMENT OF ENGINEERING.

The Department will provide courses in Mechanical and Electrical Engineering up to Ordinary National Certificate level, together with all craft courses in Engineering.

Burnham Technical Scale salary, Grade III: £1,800 by £50 to £1,950.

2. HEAD OF DEPARTMENT OF SCIENCE.

The Department will provide courses in Chemistry, Physics, Biology and Metallurgy to Advanced level G.C.E. and Ordinary National Certificate level and associated City and Guilds courses.

Burnham Technical Scale salary, Grade II: £1,600 by £50 to £1,800.

Application forms, returnable as soon as possible, and details from the Registrar, The College of Technology, Ashley Down, Bristol, 7. E8052

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

RESEARCH ASSISTANTSHIP IN THE DEPARTMENT OF STRUCTURAL ENGINEERING

Applications are invited for a RESEARCH ASSISTANTSHIP IN THE DEPARTMENT OF STRUCTURAL ENGINEERING involving interesting theoretical work on the application of electronic digital computers to structural problems. Candidates should hold a good degree in Engineering or Mathematics and have research experience. Some knowledge of computer programming would be an advantage but is not essential.

The position is tenable for three years and salary will be determined by qualifications and experience, subject to a maximum of £720 per annum. The post will be superannuable under the F.S.S.U.

Applications, giving details of experience and particulars of two referees, should be addressed to the Registrar, The Manchester College of Science and Technology, Manchester, 1, by 31st December, 1959. E8084

COLLEGE OF ADVANCED TECHNOLOGY, BIRMINGHAM

DEPARTMENT OF PRODUCTION ENGINEERING

READER (RESEARCH ENGINEER) IN PRODUCTION ENGINEERING

Applications are invited for this post from engineers capable of developing research in the fields of Machine Tools and Metrology. Previous experience in research and development and a first-class knowledge of experimental technique and instrumentation are required. The post also requires teaching duties at Post-Graduate level and in Diploma in Technology courses.

Salary Scale: Readers (Men) £1800 by £50 to £2100.

In fixing the commencing salary account may be taken of industrial, professional or research experience up to the maximum of the scale.

Further particulars and forms of applications, from the Registrar, College of Advanced Technology, Gosta Green, Birmingham, 4. Applications to be received within 14 days of this advertisement.

K. R. PILLING,
Clerk to the Governors.
E8138

PUBLIC APPOINTMENTS

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE, FARNBOROUGH, HANTS

ASSISTANT LECTURER, GRADE "B" IN ENGINEERING

Applications invited for post of ASSISTANT LECTURER, GRADE "B" IN ENGINEERING to teach general engineering subjects to H.N.C. standard. Some Dip.Tech. work may arise.

University degree or equivalent, and preferably some industrial and/or teaching experience required. Duties to commence on 1st January, 1960, or soon thereafter.

Burnham Scale for Technical Colleges: £750 by £27 10s. to £1150, plus allowances, e.g. £165 for good Hons. degree. Starting salary according to experience. Teachers' Superannuation Acts.

Application forms from Principal of College for return within 14 days. E8145

AIR MINISTRY

MEDMENHAM, ROYAL AIR FORCE, BUCKS AND WATTON, NORFOLK

CIVILIAN DRAUGHTSMEN (ENGINEERING)

Air Ministry require CIVILIAN DRAUGHTSMEN (ENGINEERING) at Royal Air Force, Medmenham, Bucks and Watton, Norfolk. Candidates must be British subjects. Duties require sound knowledge of electronics. Qualifications: O.N.C. or equivalent, satisfactory completion of normal apprenticeship or equivalent training of not less than three years and workshop experience. Salary (Provincial) £530 to £736 on entry depending on age and experience rising to maximum of £850. Five-day week and 3 weeks' 3 days' annual leave. Travelling expenses in United Kingdom in excess of 7s. 6d. will be paid to all candidates callee for interview. For application forms and full particulars, apply to Air Ministry, C.E.4b, Princes House, Kingsway, London, W.C.2, or any Employment Exchange quoting Order No. City 3308. E8027

TYNE IMPROVEMENT COMMISSION

CIVIL ENGINEERING ASSISTANTS

Applications are invited for appointment as CIVIL ENGINEERING ASSISTANTS in the Chief Engineer's Department.

Applicants should have experience in the design, construction and maintenance of dock and harbour works and installations. The salary will have regard to the qualifications and experience of the successful candidates.

The appointment will be superannuable and subject to the passing of a medical examination.

Applications, stating age, education, training, qualifications and experience, with the names of two referees should be sent to the undersigned in an envelope endorsed "Civil Engineering Assistants" not later than the 10th December, 1959.

R. N. EGGLETON,
Secretary.

Bewick Street,
Newcastle upon Tyne, 1.
24th November, 1959. E8086

BRITISH TRANSPORT DOCKS

SENIOR ENGINEERING ASSISTANTS

British Transport Docks invite applications for SENIOR ENGINEERING ASSISTANTS in the Office of the Civil Engineer, South Wales Docks, Barry, Glam.

Candidates should be Corporate members of the Institution of Civil Engineers with extensive experience in the design, specification, construction and execution of general civil engineering works, preferably with some knowledge of dock and harbour installations. Salary range £1,095–£1,265 per annum. Contributory Superannuation scheme and certain rail travel facilities.

Applications, stating age, education, training, experience and qualifications, to be sent to: Staff and Establishment Officer, British Transport Docks, 163, Euston Road, London, N.W.1, to arrive not later than Friday, 11th December, 1959. E8102

PUBLIC APPOINTMENTS

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1,095 at 34 or over, thereafter rising to maximum £1,260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. Five-day week with 4 weeks' 2 days' leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience: (i) (a) Degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years' apprenticeship, or (b) Graduate or corporate member of I.E.E. with at least 3 years' apprenticeship, or (c) Graduate or corporate member of I.Mech.E., appreciable electrical engineering experience with at least 3 years' apprenticeship, and (ii) have been employed for minimum of two years with well-established engineering concern and gained wide experience in both electrical and mechanical engineering practice. Applicants must be natural born British subjects, aged 25 to 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D 555/9A. E7944

REPUBLIC OF THE SUDAN

SUDAN RAILWAYS

SENIOR MECHANICAL ENGINEER

Applications are invited from those suitably qualified to fill a vacancy of SENIOR MECHANICAL ENGINEER in the Sudan Railways. Applicants must have the following qualifications:

Hold a degree in engineering or be Corporate Members of the Institution of Mechanical Engineers. Have served a full apprenticeship on railways or for a firm of locomotive manufacturers of repute and must have filled a position of responsibility in locomotive engineering of not less than 15 years. Should be familiar with the running and maintenance of both steam and diesel electric locomotives, have had experience on progress work and piece work and have exercised full control.

Appointments will be made on contract (with bonus) for a period of three years in the salary range from £S.1750–£S.2170 (annual increments)—the Sudanese pound equals £1 0s. 6d. sterling. Starting rate will be fixed according to age, qualifications and experience. A cost of living allowance is payable and an initial outfit grant of £S.50 on appointment. Annual home leave accrues at the rate of seven days per month.

Applications in writing quoting age, qualifications and experience with copies of two recent testimonials to The Sudan Embassy, Personnel Section, Cleveland Row, St. James's, London, S.W.1. E8131

GOVERNMENT OF NORTH BORNEO

PUBLIC WORKS DEPARTMENT

ELECTRICAL ENGINEER

For duty as Government Inspector under the Electricity Ordinance; organising and managing a small repair workshop for domestic and other electrical equipment, the servicing of such equipment and the investigation, design and construction of small electrical installations.

Contract appointment for three years in salary range £1386 to £2324 per annum with gratuity payable on satisfactory completion of contract. Outfit allowance, child allowance, free passages. Quarters at low rent. Generous home leave.

Candidates, over 28 years, must be A.M.I.E.E. or possess qualifications exempting them from the Institution's examinations, with at least 5 years' practical experience in rural and urban distribution systems and repair and service of domestic and light industrial electrical equipment, especially air conditioning equipment.

Write Director of Recruitment, Colonial Office, London, S.W.1, giving full names, age, qualifications and experience, quoting BCD 112/21/018/D4. E8117

Classified Advts. continued on page 142

PUBLIC APPOINTMENTS

ESSEX RIVER BOARD

APPOINTMENTS

The Board has the following vacancies on the permanent staff :

(a) ENGINEERING ASSISTANT, A.P.T. IV (£1065–£1220).

(b) TWO ENGINEERING ASSISTANTS, SPECIAL GRADE (£785–£1070).

Applicants for post (a) should be Chartered Civil Engineers with experience of land drainage works and will be required to act as a section leader on the design of such works. An "essential user" car allowance will be paid.

Applicants for posts (b) should be graduate members of the Institution of Civil Engineers or university graduates, with some experience of land drainage.

These posts are based at the Board's Head Office at Chelmsford.

(c) TWO DISTRICT ENGINEERS, A.P.T. I (£610–£765), A.P.T. II (£765–£880) or SPECIAL GRADE according to qualifications and experience.

Applicants for post (c) should have completed professional training or be graduate members of the Institution of Civil Engineers or university graduates, preferably with experience of land drainage. They will be required to act under the Area Engineer at either area offices at Romford or Wickford. An "essential user" car allowance will be paid.

(d) SURVEYOR INSPECTORS CLASS I, A.P.T. II.

Applicants for posts (d) should have considerable experience of River Board works and should preferably have obtained Ordinary National Certificate in a technical subject. They will be required to carry out surveys and supervise direct labour works in the area offices at Romford, Wickford or Halstead or at Head Office. In suitable cases an "essential user" car allowance may be paid.

(e) TRAINEE SURVEYORS, GENERAL DIVISION (£210–£595) or A.P.T. I (age under 21).

Successful applicants would be required to undertake simple surveying and levelling throughout the Board's area and would operate from Head Office.

All the above posts are subject to the provisions of the Local Government Superannuation Acts, 1937–1953, and successful applicants will be required to pass a medical examination.

Applications giving details of age, education, previous experience and the names of not less than two referees, which, in the case of all the above posts except trainees, should include one reference to professional ability, should be submitted to the Engineer to the Board at the address given below, not later than Saturday the 19th December, 1959.

(Signed) W. J. S. BEW,
Clerk of the Board.

Rivers House,
129, Springfield Road,
Chelmsford, Essex. E8128

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS required in following localities : LONDON AREA : MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for research on precision gear design. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles ; knowledge of theoretical hydrodynamics and theory of control mechanisms an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICIST for acoustic analysis. APPLIED MATHEMATICIAN for work with electronic computers, with special reference to research into general underwater physical problems. ELECTRONIC PHYSICISTS for data handling and analysis problems. EXPERIMENTAL PHYSICIST for research in underwater acoustics. PHYSICIST interested in operation performance. CLASSICAL PHYSICISTS.

BALDOCK : PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH : PHYSICISTS with experience in field of microwave techniques. ELECTRONIC/ELECTRO-MECHANICAL ENGINEERS (experience in servo-mechanisms an advantage).

HASLEMERE : ELECTRONIC ENGINEER.

PORTLAND : PHYSICISTS or APPLIED MATHEMATICIANS for research in underwater acoustics. PHYSICISTS (general). ELECTRICAL ENGINEERS with advanced electronic design experience. MECHANICAL ENGINEERS. PHYSICAL CHEMISTS.

POOLE : CHEMICAL ENGINEERS. CHEMISTS with experience in rubber technology.

ROSYTH : MECHANICAL ENGINEER with experience in welding development. ELECTRONIC PHYSICISTS.

Candidates must normally be natural born British subjects of natural born British parents, with First or Second-Class Hons. Degrees or equivalent qualifications. S.S.O.s must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) : S.S.O., £1233–£1460 ; S.O., £655–£1150 (London), somewhat lower in provinces.

Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those under 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.483/9A). E7844

EAST SURREY WATER COMPANY

ENGINEERING ASSISTANT

ENGINEERING ASSISTANT, preferably young man with University degree and some experience, for new works and general duties. Salary £900 to £1,000, depending on capabilities.—Apply, with names of two referees, to Chief Engineer, East Surrey Water Company, London Road, Redhill, Surrey. E8089

SCOTTISH GAS BOARD

LURGI PRESSURE GASIFICATION PLANT, WESTFIELD, FIFE

ENGINEERS AND CHEMISTS

Applications are invited from ENGINEERS AND CHEMISTS having appropriate qualifications and industrial experience for the undermentioned posts at the new Lurgi High-Pressure Coal-Gasification Plant under construction by the Board at Westfield, Fife. This plant is the first of its kind to be installed in Britain and, where necessary, successful applicants will be trained in the operation of oxygen plant, high-pressure gasification plant and ancillary processes.

ELECTRICAL ENGINEER : Salary range £1155–£1355. Responsible to Works Engineer for satisfactory operation and maintenance of all electrical equipment on the works including high- and low-voltage circuits ; and for the preparation and implementation of schemes for planned maintenance.

INSTRUMENT ENGINEER : Salary range £902–£1131. Responsible to Works Engineer for the maintenance and satisfactory operation of all instruments on the works, including process-control and recording equipment.

SENIOR PROCESS ENGINEER : Salary range £1155–£1355. Responsible, under Chemical Engineer, for supervision and integration of all works processes. Assisted by three Process Engineers.

PROCESS ENGINEER (THREE) : Salary range £902–£1235. Responsible to Senior Process Engineer for efficient operation of : (1) oxygen manufacturing plant ; (2) high-pressure gasification plant ; and (3) purification plant and high-pressure boilers.

SHIFT SUPERVISORS (FOUR) : Salary range £902–£1131. Responsible to Works Engineer for general operation of works during shift. Previous experience covering operation of gasworks, oil refinery or chemical engineering plant would be an advantage.

CHEMIST : Salary range £902–£1131. Responsible, under Chemical Engineer, for supervision and efficient running of works laboratory, and for all aspects of chemical control of plant.

Commencing salary within the ranges advertised will depend upon age, qualifications and experience ; future advancement beyond the maxima is a possibility. Consideration will be given to providing housing accommodation (on rental) in suitable cases. The posts are pensionable and successful applicants will be required to pass a medical examination.

Applications, stating age, and giving details of education, training, qualifications and experience, together with the names of two referees, should be sent to the undersigned within ten days of the appearance of this advertisement. Envelopes to be marked with the name of the post for which the application is submitted.

A. T. HERD,
Secretary.

26, Drumsheugh Gardens,
Edinburgh, 3. E8136

GUILDFORD, GODALMING AND DISTRICT WATER BOARD

APPOINTMENT OF SENIOR ENGINEERING ASSISTANT

Applications are invited for the appointment of SENIOR ENGINEERING ASSISTANT at a salary in accordance with Grade A.P.T. II (£765–£880 per annum).

Candidates should have had good experience in the general engineering work of a Water Undertaking, and have passed part of the Associate Membership Examination of the Institution of Civil Engineers.

The appointment will be subject to the National Scheme of Conditions of Service, the Local Government Superannuation Acts, and to the passing of a medical examination.

Applications, stating age, training, present and previous appointments and experience, and names and addresses of two referees, must be received by the Chief Engineer, "Branksome," Filmer Grove, Nightingale Road, Godalming, not later than Monday, the 14th December, 1959.

Housing accommodation will be available for a married man.

H. C. WELLER,
Clerk to the Board.

Municipal Offices,
High Street,
Guildford. E8023

PUBLIC APPOINTMENTS

REPUBLIC OF THE SUDAN

CENTRAL ELECTRICITY AND WATER ADMINISTRATION

RESIDENT ENGINEER

Applications are invited from those suitably qualified to fill a vacancy as RESIDENT ENGINEER with the Central Electricity and Water Administration, Sudan.

Minimum qualifications—University degree in Mechanical Engineering and/or Corporate Membership of a Professional Institution. Candidates must have had experience on erection and operation of hydro-electric plant, steam plant experience would be an advantage.

Appointments will be on contract for three or five years. Salary range £S.2050–£S.2210 per annum (£S.1 equals £1 0s. 6d.) plus cost of living allowance. A terminal bonus is payable on satisfactory completion of service.

Furnished accommodation at nominal rent and free medical attention for official and family are available. Annual leave after first eighteen months of service. Applications in writing to : The Personnel Officer, Sudan Embassy, Cleveland Row, St. James's, London, S.W.1, quoting reference 4/3200. E8132

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

DIVISION OF METROLOGY

RESEARCH ENGINEER/PHYSICIST

Applications are invited from Honours graduates in Engineering or Science, majoring in Physics or equivalent qualifications for appointment as RESEARCH OFFICER with the Organisation's Division of Metrology, National Standards Laboratory, Sydney, N.S.W.

Duties : To initiate research into and develop new and improved measuring techniques and equipment in engineering metrology, particularly in large scale metrology, dynamic metrology, gears and gear cutting equipment.

Salary : Commensurate with qualifications and experience within the ranges : £A1,365–£A1,990 p.a. or £A2,100–£A2,375 p.a. Salary for a female is £A180 p.a. less than male rates.

Fares paid. Full details supplied on application to :

Mr. E. J. Drake,
Chief Scientific Liaison Officer,
Australian Scientific Liaison Office,
Africa House,
Kingsway, London, W.C.2.

to whom applications (quoting Appointment No. 750/204) should be addressed by the 15th January, 1960. E8119

REPUBLIC OF THE SUDAN

CENTRAL ELECTRICITY AND WATER ADMINISTRATION

ASSISTANT CHIEF ENGINEER

Applications are invited from those suitably qualified to fill a vacancy of ASSISTANT CHIEF ENGINEER (GENERATION) with the Central Electricity and Water Administration, Sudan.

Minimum qualifications—University degree in Mechanical Engineering and/or Corporate Membership of a Professional Institution. Experience on steam power station design and operation is essential. Diesel power station experience would be an advantage.

Appointment will be on contract for three or five years. Salary range £S.2,050–£S.2,210 per annum, plus cost of living allowance (£S.1 equals £1 0s. 6d.). Furnished accommodation at nominal rent, free medical attention for the official and family are available. Annual leave after the first eighteen months of service.

Applications in writing to : The Personnel Officer, Sudan Embassy, Cleveland Row, St. James's, London, S.W.1. Quote reference 4/3201. E8133

ELECTRONIC ENGINEERS

required for development, planning, manufacture or inspection of
GUIDED MISSILE & OTHER ELECTRONIC EQUIPMENT
by
MINISTRY OF AVIATION
at BLACKBURN, Lancs, LONDON and OTHER LOCATIONS
EXCELLENT CAREER PROSPECTS
Posts in Professional Engineer Basic Grade
Starting Salary £780–£1,300 p.a. according to age and location.
Opportunities for established appointments arise.

Engineering apprenticeship or equivalent and corporate membership of Institution of Electrical Engineers, or exempting qualification required. Experience of modern electronic practice in communication or radar fields desirable. Knowledge of guided weapons practice and servo-mechanisms an advantage.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D.478/9A/BFD.

E8081

PUBLIC APPOINTMENTS

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL ENGINEERING LABORATORY, EAST KILBRIDGE, GLASGOW

ASSISTANT EXPERIMENTAL OFFICER METALLURGIST

D.S.I.R. National Engineering Laboratory, East Kilbride, Glasgow, requires ASSISTANT EXPERIMENTAL OFFICER METALLURGIST with practical knowledge of metallographic techniques and preferably with experience of ferrous materials. Qualifications : G.C.E. "A" level in two Science or Mathematical subjects or equivalent. Over 22, Pass degree, H.N.C. in metallurgy or equivalent generally expected. Salary range : £382 10s. to £830. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting reference F 34/9A. E8115

SWINDON CORPORATION WATER UNDERTAKING

APPOINTMENT OF PRINCIPAL CIVIL ENGINEERING ASSISTANT

A.P.T. GRADE "V" (£1220–£1375)

Applications are invited for the above new appointment in the WATER SECTION of the Borough Surveyor and Water Engineer's Department.

The person appointed will be directly responsible to the Deputy Water Engineer for the civil engineering development work in this rapidly expanding Water Undertaking. Applicants should have had considerable experience in underground water supply, service reservoirs and trunk mainlaying work, and should be Corporate Members of the Institution of Civil Engineers and of the Institution of Water Engineers.

Applications on forms to be obtained from the Town Clerk, Civic Offices, Swindon, must be returned not later than 31st December, 1959. E8046

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

HYDRAULICS RESEARCH STATION, HOWBERRY PARK, WALLINGFORD, BERKS

SCIENTIFIC OFFICER ENGINEER OR PHYSICIST

D.S.I.R. Hydraulics Research Station, Howberry Park, Wallingford, Berks, requires SCIENTIFIC OFFICER ENGINEER or PHYSICIST with knowledge of engineering and fluid dynamics for studies of hydraulic problems in field of Civil Engineering including scale model investigations and basic research. Qualifications : 1st or 2nd Class Hons. degree in Civil Engineering or Physics, or equivalent. Salary range : £615 to £1,090. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.489/9A. Closing date 31 December, 1959. E8114

TENDERS

DUNMOW RURAL DISTRICT COUNCIL

HATFIELD HEATH AND HATFIELD BROAD OAK SEWERAGE AND SEWAGE DISPOSAL

CONTRACT NO. 16

TENDERS are invited on a fixed price basis in accordance with the Ministry of Housing and Local Government Circular No. 31/57 for the CONSTRUCTION OF SEWERAGE AND SEWAGE DISPOSAL WORKS at Hatfield Heath and Hatfield Broad Oak.

The sewerage in Hatfield Heath and Hatfield Broad Oak, comprises in all the laying of about 1310 linear yards of 9in. diameter S.G.W. sewer, 780 linear yards of 6in diameter S.G.W. sewer, 830 linear yards of 6in. diameter spun iron rising main, 4in. and 6in. diameter S.G.W. house connections, construction of 7 brick and 12 precast concrete manholes, together with a sewage pumping station in reinforced concrete.

Extensions are to be made to the existing sewage disposal works at Hatfield Heath and comprise the construction of sand filters in reinforced concrete, together with ancillary pipework.

General Conditions of Contract, Specification, Bills of Quantities and Drawings may be obtained from the Council's Consulting Engineers, Messrs. J. D. and D. M. Watson, MM.I.C.E., 67, Tufton Street, Westminster, S.W.1, on and after 7th December, 1959, on payment of a deposit of ten guineas, refundable only to Contractors who submit bona fide tenders and return all documents and drawings. Deposit cheques should be made payable to Dunmow Rural District Council.

The Council do not bind themselves to accept the lowest or any tender.

Tenders must be returned in envelopes which do not bear any name or mark indicating the sender, endorsed "Tender for Sewerage Contract 16," and delivered at the office of the undersigned by noon on 15th January, 1960.

A. H. BURTON,
Clerk of the Council.

Council Offices,
Dunmow, Essex. E8045

TENDERS

CITY OF LEEDS

WATERWORKS DEPARTMENT

YORK ROAD RE-DEVELOPMENT AREA

BOOSTER PUMPING STATION

The Waterworks Committee of the Leeds City Council invites TENDERS for the SUPPLY, ERECTION and MAINTENANCE of an ELECTRICALLY DRIVEN AUTOMATIC BOOSTER PUMPING PLANT having a capacity of 140 gallons per minute against a total head of 150ft. complete with Switchgear, Motors, Time Controls, Air Pressure Tank, Air Compressor, Piping and Valves.

Plan, Specification and Forms of Tender and Instructions to Persons Tendering may be obtained upon application to the undersigned.

Forms of Agreement and Conditions of Contract and the Institution of Electrical Engineers General Conditions of Contract (Home Contracts—With Erection) may be seen at the Waterworks Department, Room 15, Civic Hall, Leeds, 1.

The Waterworks Committee does not bind itself to accept the lowest or any Tender.

Tenders must be enclosed in plain sealed covers endorsed "Tender for Pumping Plant—Waterworks" and be delivered at the Town Clerk's Office, Room 57, Civic Hall, Leeds, 1, not later than 12 noon on Friday, 1st January, 1960.

KENNETH L. FORSTER, M.I.C.E.,
General Manager and Engineer.

Civic Hall,
Leeds, 1. E8148

INDIA STORES DEPARTMENT

The office of the Directorate General of Supplies and Disposals, N.I.C. Building, Parliament Street, New Delhi, India, invites TENDERS for the following :

D.G.S. & D. TENDER ENQUIRY SE-7/3563-K/1

For the SUPPLY of DRAGLINE AND SHOVEL EXCAVATORS. Capacity 2¼ cu. yard, ¾ cu. yard Clamshell and Bottom and Rear DUMPERS, payload capacity 40,000 lbs. each. Required for the Kosi Project.

Specifications, drawings, etc., relative to the above, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 15 shillings per tender and is not refundable. Tenders are to be returned to the Directorate General of Supplies and Disposals, N.I.C. Buildings, Parliament Street, New Delhi, India, so as to reach them by 29th January, 1960.

Specimen copy of the above enquiry can be seen at India Stores Department, Engineering Branch, Bromyard Avenue, Acton, W.3, under the following reference S.3789/59/NSC/ENG.2. E8137

GOVERNMENT OF NEW ZEALAND

MINISTRY OF WORKS

WAIRAKEI GEOTHERMAL PROJECT "B" STATION CIRCULATING WATER MAINS AND AUXILIARY WATER SUPPLIES

TENDERS will shortly be invited for the SUPPLY ONLY of circulating Water Mains and Auxiliary Water Supplies, comprising some 900ft. of 72in. pipe, 80ft. of 48in. pipe, 420ft. of 42in. pipe, 210ft. of 33in. pipe and ancillary pipework of smaller diameters and associated equipment.

Firms who are interested should apply to Merz and McLellan, "Milburn," Esher, Surrey, for further particulars. No further announcement will appear in the Press and manufacturers should regard this notice as the formal invitation to Tender. E8085

TENDERS

INDIA STORE DEPARTMENT

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the Supply of :

	Quantity Nos.
HELICAL SPRINGS FOR BOGIE BOLSTER IN SILICO MANGANESE SPRING STEEL...	1540

Forms of Tender may be obtained from the above address on or after the 4th December, 1959, upon payment of a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenderers must send their Tenders so as to reach this Office by 2 p.m. on Thursday, 7th January, 1960.

Please quote Reference No. 44/59. DB/RLY.2. E8108

EDUCATIONAL

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, ST. JOHN STREET, LONDON, E.C.1

A Short Course on THE REGENERATIVE-REHEAT STEAM CYCLE will be conducted by C. D. Weir, B.Sc., Ph.D., A.M.I.Mech.E., A.I.M. (Kennedy and Donkin, Consulting Engineers) on Monday, 14th and Tuesday, 15th December, 1959.

The fee for the course will be £6 6s. 0d. Applications should be sent to the Secretary from whom further details of the course are obtainable. E8135 E

A.M.I.MECH.E., B.Sc., City and Guilds, etc. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent successes.. 148-page prospectus free, on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AIR CONDITIONING ENGINEER

Able to handle complete schemes from enquiry to completion on own initiative. Interesting and varied work. Good salary. Pension Scheme. South London district. Qualifications, age, salary required.—BOX No. E8116, "The Engineer." A

AIR TREATMENT ENGINEER required for group of Mills near Manchester. Applicants should be capable of preparing schemes and estimates for new plants, and supervising erection and maintenance. Please state experience, technical qualifications and age.—BOX No. E8130, "The Engineer." A

AN OLD EST. INDUSTRIAL CONCERN in pleasant surroundings in N.W. England has a vacancy for an ASSIST. MECH. ENG. whose work would mainly be connected with the installation and maintenance of medium to heavy plant. Minimum qualifications—a recognised apprenticeship and H.N.C. in Mech. Eng. Previous experience in Planned Maintenance an advantage. Pensionable position with excellent opportunities for gaining additional experience. Full particulars.—BOX No. E2644, "The Engineer." A

BOOKS and PUBLICATIONS

PITMAN

TECHNICAL BOOKS

FROM ALL BOOKSELLERS

FUNCTIONS OF COMPLEX VARIABLES

By Philip Franklin. This book is outstanding for its clear and precise explanation of a branch of mathematics which has often been obscured in a haze of highly abstract concepts. Logical and essentially complete, its purpose is to introduce the reader to the general properties of an analytical function of a single complex variable. 25/- net.

TRANSFORMERS

By F. C. Connelly, Ph.D., etc. Here, gathered into one volume for the first time, is information about the different types of transformers required in line and radio communication, radio-frequency heating, electronics, portable machine tools, electro-medical equipment, illumination, and measuring apparatus. 35/- net.

STRENGTH OF MATERIALS FOR ENGINEERS

By D. R. Axelrad, Dipl. Ing., A.M.I.Mech.E., etc. This new book meets the requirements of students preparing for Engineering Degree examinations and those of the professional bodies. Of value also to practising engineers, the book includes a large number of worked examples and additional problems taken from examination papers. 55/- net.

Parker St., Kingsway, London, WC2

Enter No. 1431 on reply card

SITUATIONS VACANT

APPLICATIONS ARE INVITED for the post of SENIOR JIG AND TOOL DRAUGHTSMAN, with experience in machining light alloys for Drawing Office in Southern England. Write stating age, details of experience, qualifications and salary required.—BOX No. E8141, "The Engineer." A

APPLICATIONS ARE INVITED from ambitious and resourceful men to fill the position of TECHNICAL ASSISTANT to the Sales Manager of Electric Lamp Machinery Manufacturers near London. A permanent, progressive and interesting job is offered to the right person, who must possess a sound engineering and commercial background in the trade.—Applications, with full particulars of education, experience and salary required to BOX No. E171, "The Engineer." A

BRITISH WATERWAYS require an ENGINEERING ASSISTANT at Gloucester ; salary range £798–£876 per annum. Candidates should have experience in design and execution of Canal works and general administrative experience. Preference will be given to applicants holding an Engineering degree and/or who are graduates of the Institution of Civil Engineers. If eligible will be required to join contributory superannuation scheme. Certain privilege rail travel available.—Applications, giving details of age and past experience to reach Divisional Manager, British Waterways, South Western Division, Dock Office, Gloucester, by 14th December, 1959. E8140 A

CRANE DESIGNER DRAUGHTSMAN required in the West Riding, Yorkshire, with sound knowledge of Overhead Travelling Cranes. Age 30 to 40 years. The work is interesting and of varying nature, and the future prospects are excellent. House provided if necessary. Give details of experience and salary required.—BOX No. E8142, "The Engineer." A

DESIGNER-DRAUGHTSMAN required, preferably with H.N.C. in Mechanical Engineering. Non-contributory pension scheme available.—Applications to Metalectric Furnaces, Ltd., Cornwall Road, Smethwick, 40, Staffs. E2638 A

DESIGN DRAUGHTSMEN FOR SOUTH AFRICA

A leading heavy engineering works in SOUTH AFRICA requires DESIGN DRAUGHTSMEN with mechanical engineers diploma, Higher National Certificate or equivalent. Sound theoretical knowledge of mechanical engineering, design methods and at least five years' practical experience in medium/heavy engineering essential.

Housing available. Pension and medical benefit funds.

Salary in accordance with qualifications and experience. Facilities exist for advancing travelling expenses to South Africa on contract basis.

Applications, stating age, qualifications, present salary, previous experience, and marital status, must be addressed to BOX 729, c/o Walter, Skinner, Ltd., 20, Copthall Avenue, London, E.C.2. E8031 A

DESIGN ENGINEER FOR AUSTRALIA. Applications invited for DESIGN ENGINEER experienced in design of current and voltage transformers, voltages up to 132,000 volts. Age 25-30 years. Electrical engineering degree or H.N.C. diploma required.—Write with full details to BOX No. 3036, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E8079 A

ELECTRO-MECHANICAL AND SMALL PRECISION MECHANISM, DESIGN AND DETAIL DRAUGHTSMEN required for interesting projects in Central London offices. Excellent conditions. Top salaries paid. Superannuation scheme. Write, giving full details, Ref. GM.—BOX No. E8107, "The Engineer." A

ENGINEERING, PHYSICS AND SCIENCE GRADUATES required for research on the dynamic behaviour of machine tools and problems associated with the automatic control of machine tools. Opportunities will be given for developing results of research into new conceptions of machine design. Prospects are good for those having capacity for original thought and ability, and initiative to take complete control of any project. Superannuation scheme. Good working conditions.—Send full details in confidence to the Secretary (R.612), Production Engineering Research Association, Melton Mowbray, Leics. E8153 A

GRADUATES in Mechanical and Chemical Engineering, Physics and Applied Mathematics required to work on the experimental and theoretical development of fuel elements and other aspects of nuclear reactors. Extensive laboratory facilities are available and ancillary equipment includes both digital and analogue computers. Practical engineering training and research experience will be considered advantageous but are not necessary requirements.—Apply Personnel Manager (DWB/13), The General Electric Company, Limited, Erith, Kent. E8097 A

PILKINGTON BROTHERS LIMITED have a number of vacancies for experienced MECHANICAL DRAUGHTSMAN DESIGNERS. The work would include design work of light, medium and heavy machines, under the direction of the Chief Designer in the Central Engineering and Planning Department.

Minimum qualifications H.N.C. Good drawing-office experience.

Assistance with house purchase, recreational and canteen facilities, five-day week, superannuation scheme.

Applications should be addressed to Group Staff Department, Pilkington Brothers Limited, Grove Street, St. Helens, Lancashire. E8112 A

PLANT DESIGN ENGINEER.—Applications are invited from Graduates, or equivalent, aged 30–35, with design and site experience in the Chemical or Oil Industries, enabling them to carry responsibilities including plant layout, piping design and interpretation of the line diagrams. The salary is good and the appointment is permanent and pensionable. Letters, which will be treated in confidence, should be sent to : The General Manager, Humphreys and Glasgow, Limited 22, Carlisle Place, London, S.W.1. E8151 A

MECHANICAL/ELECTRICAL DRAUGHTSMAN required by Consulting Engineers. Experience of water and sewage treatment machinery desirable.—Apply to John Taylor and Sons, Artillery House, Artillery Row, S.W.1, giving details of experience and salary required. E8098 A

MECHANICAL SUPERINTENDENT, aged 30-40, required by open cast Mining Company in WEST AFRICA. Considerable managerial and organising ability essential and experience with mechanical plant, including operation, maintenance and overhaul of excavators, crawler tractors, scrapers and similar earth moving equipment. Commencing salary £2000 per anunm plus 5 per cent bonus, for married man separation allowance of £10 per month and £5 per month for each child. Return passage paid, free furnished quarters and medical attention. Life Assurance and Dependants Income Scheme.—Write, giving full details experience, stating age, married or single, to SIERRA LEONE DEVELOPMENT CO., LTD., Dept. M.S.6, City Gate House, Finsbury Square, London, E.C.2. E8094 A

PORT OF MANCHESTER ENGINEERING APPOINTMENT

Applications are invited for a senior position on the staff of the Chief Engineer.

The position is one which offers excellent prospects of promotion and will carry a salary commensurate with the responsibilities entailed.

Candidates, who must be Corporate Members of the Institution of Civil Engineers, should not only have extensive experience in dock and harbour construction and maintenance but should also have first-class executive and administrative experience.

The successful candidate will be required to pass a medical examination and to become a member of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications and full details of experience, should be addressed to the Chief Engineer, (marked "Personal") The Manchester Ship Canal Company, Ship Canal House, King Street, Manchester, 2, not later than the 15th January, 1960. E8149 A

PROGRESS MAN, with good engineering or industrial background, able institute and run complete system for London engineers. New and interesting work requiring the development of appropriate progress techniques. Staff pension scheme and output bonus. Write full details experience and state salary required.—BOX No. E8129, "The Engineer." A

PUMP ENGINEER required for work on the application and specification of Centrifugal Pumps. It is envisaged that suitable applicants will be not less than 30 years of age and have had a minimum of ten years' experience in connection with the manufacture of all types of Centrifugal pumps. They will probably be at present engaged as a Section Leader in the Drawing Office of a reputable firm of pump manufacturers, or in some similar capacity. Give full details regarding age, experience, present position, technical qualifications, and salary required.—BOX No. E8014, "The Engineer." A

QUALIFIED ENGINEERS with considerable experience of pipeline pump station and tank farm construction required by important firm for Middle East.—State age and full details to BOX No. 3052, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E8144 A

SENIOR DESIGN DRAUGHTSMEN, familiar with small mechanisms, etc., required by progressive and expanding Company situated approximately 20 minutes from Waterloo. The positions offered are permanent and provide excellent prospects for versatile men who seek interesting work in a new field.—BOX No. E169, "The Engineer." A

SENIOR DESIGNER/DRAUGHTSMAN required for Steelworks Consultants in the Midland area. Steelworks experience desirable but not essential. The position is a progressive one and salary will be dependent on qualifications and experience. Non-contributory pension scheme.—Applications, giving age, qualifictions and experience, to The Salem Engineering Co., Ltd., Milford House, Milford, Derbys. E8154 A

SENIOR DRAUGHTSMAN.—May and Baker Ltd., Dagenham, Essex, require a SENIOR DRAUGHTSMAN with experience in the design and layout of chemical or similar plant installations. Applicants should have technical qualifications to Ordinary National Certificate level or higher. Salaries are reviewed annually. There is a Pension Fund and Life Assurance Scheme in operation. Excellent canteen and sports facilities.—Apply initially in writing to the Personnel Officer, quoting Reference No. 154/59. E8083 A

SENIOR PROJECTS ENGINEER required for layout, design and specification of plant. Must have extensive experience of mechanical handling, vessels and pipework, brewery plant or bottling machinery. Also INTERMEDIATE DESIGN DRAUGHTSMAN required, at least 2 years' D.O. experience (mechanical) ; practical training and O.N.C. preferred. Salaries commensurate with experience, qualifications and responsibilities. Canteen. Pension scheme.—Apply in writing with full particulars, Chief Designer, G. HOPKINS AND SONS, LIMITED, United House, North Road, London, N.7. E8040 A

STEEL TUBES.—WORKS MANAGER required. Must have wide experience in practical and executive appointments, held similar positions and be a first-class administrator. Substantial salary will be paid to man with necessary qualifications and future prospects are excellent.—Apply in confidence to the Managing Director, The Phoenix Steel Tube Co., Ltd., Phoenix Street, West Bromwich. F7920 A

STRUCTURAL ENGINEERING DESIGNER required in London office of Consulting Engineers. Should have a University Degree in Engineering or the Associate Membership of either the Institutions of Civil or Structural Engineers and must have had at least one year's experience on the design of structural steelwork. Some experience on reinforced concrete design would also be an advantage. Salary according to experience. Five-day week. Pension scheme. Luncheon vouchers. Apply, stating age and experience.—BOX No. E8152, "The Engineer." A

Classified Advts. continued on page 144

SITUATIONS VACANT

SENIOR RATEFIXER / METHODS ENGINEER required for Fabrication work. Experience of machine shop practice and electrical work would be an advantage. Salary according to experience.—Replies, in confidence, to Works Manager, H. and E. Lintott, Ltd., Foundry Lane, Horsham, Sussex.
E7997 A

SUPERVISOR FOR MECHANICAL SERVICES

An experienced Engineer required by Main Contractors to ensure that work of Specialist Sub-Contractors is being carried out efficiently and according to specification. He should be familiar with services in large industrial plants, including electrical, heating, ventilating, chemical and gaseous services. Experience of the design of such services would be helpful and also ability to vet and advise on specifications at tender stage. Sphere of operations mainly in Northern England. Excellent staff conditions, pension scheme, etc.

All applications will be treated confidentially but must contain full details of past and current employment, age, education, qualifications and approximate salary required.—BOX No. E8139, "The Engineer."
A

TECHNICAL REPRESENTATIVE (OUTSIDE) wanted for Sheet Metal Machines and Machine Tools. South London and home counties area. Non-contributory pension and assurance scheme.—Write in full to Managing Director, F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1. E8150 A

TECHNICAL SALES

Applications are invited for the appointment of an additional qualified ENGINEER in the Sales Department of an expanding engineering company in S.W. London supplying specialised machinery to the paper and box-making industries throughout the world. Applicants should be between 25 and 32 years of age, possess a degree or H.N.C. in mechanical engineering and have served an apprenticeship.

Previous sales experience is not necessary. The work is responsible and interesting, entailing the discussion of both technical and commercial problems with existing and potential customers and requires outstanding personal qualities.—Applications, with full details of education, qualifications, age and experience, to be sent to BOX No. E8087, "The Engineer."
A

TELEMETRY AND CONTROL ENGINEER

A vacancy occurs with a leading Oil Company for an experienced Engineer with suitable academic and/or professional qualifications.

Applicants should have had design and operational experience of telemetering relating to plant operation, control and instrumentation. A knowledge of V.H.F. multi-channel systems carrier and associated equipment would be advantageous.

The successful candidate would work in London but may be required to travel overseas for short periods. The post carries a non-contributory pension scheme and the salary range is £1000 to £1400 p.a., depending on experience and qualifications.

Write, giving full details of experience and personal particulars, to BOX TE 485, c/o 191, Gresham House, E.C.2. E8105 A

THE PERMUTIT COMPANY LTD.

invite applications from a
SENIOR MECHANICAL DESIGN DRAUGHTSMAN, with experience in design of hydraulic control equipment,
and a
SENIOR ELECTRICAL DRAUGHTSMAN with experience in design of automatic control circuits and instrumentation.

These are permanent and pensionable positions with a good starting salary. Please apply to :—The Personnel Officer, Permutit House, Gunnersbury Avenue, W.4. E8104 A

TRANSFORMER WINDER FOR AUSTRALIA.—Applications invited for TRANSFORMER WINDER experienced in winding all types of transformer coils. Apprenticeship in transformer field required and knowledge of high voltage work necessary.—Write with full details to BOX No. 3037, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E8078 A

WORK STUDY

A major industrial organisation requires a trained WORK STUDY ENGINEER with 3 to 5 years' experience in medium industry. The successful candidate must be able to work without detailed supervision and should also have some knowledge of mechanical handling. This is an interesting position and prospects are quite bright. Please write, stating full details of age, experience and qualifications.—BOX No. E8113, "The Engineer."
A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, "The Engineer."
A

SENIOR MECHANICAL ENGINEER

Minimum B.Sc. in Mechanical Engineering, with 10 years' experience in the design and selection of centrifugal and reciprocating compressors and prime movers, refrigeration systems, blowers and ancillaries as applied to compression equipment.

He will be required to originate specifications for all mechanical and ancillary equipment for cryogenic plants, review and recommend equipment from proposal stage, prepare operating instructions and to site inspect for commissioning and to develop prototype designs within the company and with manufacturers.

Apply, Personnel Manager,
AIR PRODUCTS (GB) LTD.,
49/50, Poland Street, London, W.1.

E8110 A

A MACHINE SHOP SUPERVISOR

is required by

TEXACO TRINIDAD INC.,

for service in Trinidad, W.I.

Applicants must have served a full apprenticeship in heavy engineering and reached Foreman, or at least Section Leader stage. They should have long continuous experience of jobbing shop practice, including sheet metal work, welded fabrications, blacksmithing and heat treatment and should also have a knowledge of work planning and rate fixing. Technical education must be at least to the level of Ordinary National Certificate in Mechanical Engineering.

The starting salary for this pensionable position is in the region of £1300 p.a., and subsidised accommodation and schooling for children will be available.

Please write with brief particulars to the :
Personnel Officer,
TRINOIL (U.K.), LIMITED,
29/30, Old Burlington Street, London, W.1.

E8146 A

THE GARRARD ENGINEERING AND MANUFACTURING CO., LIMITED,

are desirous of obtaining the services of a

DESIGN ENGINEER

Applications are invited from YOUNG ENGINEERS who :

(i) have served an engineering apprenticeship.

(ii) have obtained at least Ordinary National Certificate, Engineering.

(iii) have at least two years' drawing office experience on the design of Small Mechanisms.

The Company are engaged on work of a light Electro Mechanical Nature and the successful applicant will have the opportunity of following his work through from drawing board to Production Line.

The Company consider their staff conditions to be good and operate a non-contributory pension scheme. Assistance with housing can be given if required.

Applications in confidence should be addressed to :

THE CHIEF PERSONNEL OFFICER,
THE GARRARD ENGINEERING AND MANUFACTURING CO., LIMITED,
Newcastle Street,
SWINDON, WILTSHIRE.

E8024 A

PROJECT ENGINEERS

required by Company engaged in the engineering, manufacturing and erection of low temperature process plants.

Applicant must hold Degree or its equivalent in Chemical or Mechanical Engineering, have two years' experience of Project Engineering and three years in the Chemical Process or Allied Industries.

Write : Personnel Manager,
AIR PRODUCTS (GB), LTD.,
49/50, Poland Street,
London, W.1.

E8109 A

JOHNSON, MATTHEY & CO., LIMITED

DESIGN ENGINEER

Aged 23-33, with good drawing-office background, is required for the Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential.

The work entails handling projects from the drawing-board through to construction and running in for production.

Conditions of service include free lunches and an annual bonus, also a contributory pension scheme. Salary according to age, qualifications and experience.

Write, giving full details of age, qualifications, experience, &c., to the Secretary, Johnson, Matthey & Co., Limited, 78, Hatton Garden, London, E.C.1.

E8030 A

FORD

require a

PRODUCT ASSISTANT

Applicants must have :

★ Technical engineering experience and be capable of reading engineering drawings.

★ A lively interest and knowledge of competitive car and truck designs and the ability to argue their technical points with designers.

★ A sound knowledge of the composition of costs and an unusually keen product interest.

If you match up to these requirements and are keen to join an ambitious and expanding organisation, please send full details of age, experience, qualifications and salary requirements to Mr. H. G. Pearman, Training and Recruitment Department, Ford Motor Company Limited, Dagenham, Essex, quoting reference APA.

E8101 A

ENGINEERS . . . . .

Applications are invited for the following positions by a major contracting organisation engaged on the mechanical and civil engineering design and construction of large-scale Oil Refineries, Chemical and Petrochemical plants.

PROJECT ENGINEER

who will be responsible for the co-ordination of specialist design groups and liaison with clients. Applicants should already be in a similar position and hold either A.M.I.Mech.E. or A.M.I.Chem.E.

Commencing salary £2000 p.a.

SENIOR PIPING ENGINEER

experienced in the preparation of specifications, requisitioning and engineering analysis and fully conversant with British and American standards and codes of practice.

Commencing salary £2500 p.a.

VESSEL ENGINEER

must hold A.M.I.Mech.E. and be thoroughly familiar with British and American specifications and codes of practice, basic design, works and field fabrication and engineering analysis.

Commencing salary £2000 p.a.

CIVIL DESIGN ENGINEER

must have had at least 8 years' experience, preferably including at least 3 years in a contracting company.

Commencing salary up to £2000 p.a.
according to experience.

CIVIL (SITE) ENGINEER

required for the supervision of civil engineering work on large oil Refinery and Chemical plant construction sites. Must have had at least 10-15 years' sound experience.

Commencing salary £1500 p.a.

Please write, giving full details, in confidence.—BOX No. E8143, "The Engineer."
A

SITUATIONS VACANT

CHEMICAL ENGINEER

Applications are invited for a position in the Development and Research Department from Associate Members of the Institute of Chemical Engineers or persons holding an equivalent University qualification. Candidates should be under 30 years of age and experience of development work in the heavy chemical industry would be an advantage. Assistance will be given towards housing and removal expenses and a commencing salary of £700–£900 per annum is envisaged to a suitably qualified person. Please send full details in writing to the Secretary, West Norfolk Fertilisers, King's Lynn, Norfolk.

E8092 A

SITUATIONS VACANT

QUALIFIED SALES ENGINEERS WANTED

in various areas to represent Machine Tool Manufacturers and Importers of special high quality equipment. Age 30 to 40. Previous experience essential. Salary according to qualifications and experience. Very good prospects for right applicants.

Apply BOX No. E2645, "The Engineer."

A

SITUATIONS VACANT

PRESSED STEEL COMPANY LIMITED

The Company is engaged in large-scale manufacture of Motor Car Bodies, Commercial, Domestic and Industrial Refrigeration Plant and Railway Rolling Stock and employs some 20,000 in Plants at Oxford, Swindon, Reading and Paisley. In order to meet a continuously expanding Design and Development Programme, applications are invited for appointments as :—

FACTORY PLANNING ENGINEERS

Candidates should be well qualified technically, with considerable experience covering all aspects of Plant, Building and Machinery and in particular in the Shop loading of Plant and Machinery.

These appointments offer the opportunity for those with experience in the above-mentioned capacity to join an expanding Organisation. Conditions of employment accord with best industrial practice. Applications, with full details of education, training, experience and salaries earned, may be made to the Staff Officer, Pressed Steel Company Limited, Cowley, Oxford, where the successful applicants will be located.

E8124 A

SITUATIONS VACANT

MSL *have been retained to advise on the appointment of an*

ASSISTANT WORKS MANAGER

for the structural works of a company manufacturing a variety of heavy steel buildings, bridges and docks equipment. The company, founded over 80 years ago, employs about 2,000 on current major projects.

The Assistant Works Manager will be responsible to, and will deputise for, the Works Manager in the control of production, programming and inspection within the structural works with 500 employees, and in its general administration. Candidates must be qualified structural or civil engineers with experience of heavy steel fabrication and welding.

Preferred age about 35 years. Initial salary not less than £1,500 with pension, life assurance and bonus schemes. Assistance with removal expenses and housing may be arranged.

Please send brief details in confidence, quoting reference G.1932, to J. G. Smith. In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
212, West Regent Street, Glasgow, C.2.

E134 A

BCL

A DEPUTY DEVELOPMENT ENGINEER

is required by

BRITISH CELLOPHANE LIMITED

Applications are invited from Engineers with good Honours degrees who have completed a post-graduate apprenticeship and have had some years' industrial experience, preferably in the sphere of design of process plant, services and auxiliary equipment. The successful applicant will be responsible to the Development Engineer for the work of an extensive team engaged on the design and development of continuous process plant and services. The duties include preparation of projects and estimates, and commissioning of plant, with later investigation of performance of plant and equipment.

The position is one of responsibility and requires a man in the age group 30–40, with initiative and ideas, who is fully conversant with present-day workshop techniques and materials of construction.

Applications, including brief details of qualifications, experience and date of birth, should be addressed to :—

The Personnel Officer,
Bath Road, Bridgwater, Somerset.

E809 A

DESIGN ENGINEER

required by British Jeffrey-Diamond Limited, Wakefield, with wide experience of Hydraulic circuits and control mechanisms, Pumps, Motors, Valves, etc. This is an important appointment with a long-established Company of good standing and prospects are outstandingly good for a man having the necessary practical and technical knowledge and experience.

Applications, giving full details of age, experience and technical qualifications should be addressed to the Secretary.

E8121 A

SENIOR DRAUGHTSMEN

experienced in bulk mechanical handling or foundry work. Superannuation Scheme. Five-day week. Apply to MARCO CONVEYOR & ENGINEERING COMPANY Ltd., 42, George Road, Edgbaston. Birmingham, 15. Edgbaston 4980.

E8020 A

ELECTRICAL ENGINEER

wanted by leading German manufacturer for German-English translations. Applications are invited from British-trained engineers with a good general education and sound technical training, preferably also with practical experience in the application of electric equipment. Good working knowledge of German is essential. The ability to write clearly and concisely will be expected of candidates. A five-day week is worked with generous holidays. Favourable housing conditions for permanent staff.—Apply, stating age, education, qualifications, experience and salary required. —BOX No. E8059, "The Engineer."

A

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Applications are invited for the following appointments in the

RESEARCH TEAM LOCATED AT LITTLEBROOK POWER STATION, DARTFORD, KENT.

The team is developing an advanced steam cycle for power generation employing steam at 1400°F as the working fluid for a "gas" turbine as proposed by J. F. Field (Proceedings, I.Mech.E., V. 162, P. 209, 1950 refer). A portion of the steam is bled from the "gas" turbine circuit and passed through a condensing turbine before re-entry into the primary circuit. The cycle, which contains many unorthodox features and presents many exciting problems, could conceivably be operated with coal, oil or nuclear fuel and provides an opportunity to gain experience in many aspects of power generation.

A superheater with steam capacity of 100 k.lb. per hour is nearing completion and a 15MW pilot plant is planned.

MECHANICAL ENGINEER

The mechanical engineer should be capable of directing a team working on steam cycle analysis and thermodynamic studies relating to both the superheater and the pilot plant.

Candidates should preferably hold a good honours degree with several years' experience with steam plant and have a lively interest in thermodynamics and the theoretical aspects of steam engineering.

The salary will be on a scale within the range £1590–£2045 p.a., according to duties and responsibilities.

ENGINEERS, PHYSICISTS, MATHEMATICIANS

A programme of both theoretical and experimental work is envisaged and successful candidates will assist in running the experimental steam superheater and in the design and subsequent operation of 15MW pilot generating plant mentioned above. They will also be required to study problems involving one or more of the following :—

The thermodynamics and aerodynamics of steam and gas turbines and axial flow compressors, radiant and convective heat transfer, combustion technology associated with P.F. and oil-firing, corrosion resistance and high temperature metallurgy.

Candidates should preferably have an honours degree, with a strong inclination for research and development work.

Salaries will be on scales within a range rising to £1,350 p.a., according to duties and responsibilities. Promotion prospects are good in an expanding organisation.

Applications, stating age, qualifications, experience, present position and salary, should be forwarded to the Personnel Officer, 24 30, Holborn, London, E.C.1, by 18th December. Envelopes should be marked "Confidential Ref. ENR 459."

Candidates who are interested and would like to have further preliminary information about these posts are invited to telephone Chancery 2866, Ext. 30.

E8093 A

CRANE DESIGNER

A prominent crane building company in the Glasgow area have a vacancy for

A MODERN CRANE DESIGNER

Applicants should state experience in this class of work, and educational certificates held. Good working conditions. Contributory Pension and Free Life Insurance Scheme. Salary commensurate with experience and ability. State when free to start.—BOX No. E8118, "The Engineer."

A

Classified Advts. continued on page 146

SITUATIONS VACANT

SENIOR RATEFIXER / METHODS ENGINEER required for Fabrication work. Experience of machine shop practice and electrical work would be an advantage. Salary according to experience.—Replies, in confidence, to Works Manager, H. and E. Lintott, Ltd., Foundry Lane, Horsham, Sussex.
E7997 A

SUPERVISOR FOR MECHANICAL SERVICES

An experienced Engineer required by Main Contractors to ensure that work of Specialist Sub-Contractors is being carried out efficiently and according to specification. He should be familiar with services in large industrial plants, including electrical, heating, ventilating, chemical and gaseous services. Experience of the design of such services would be helpful and also ability to vet and advise on specifications at tender stage. Sphere of operations mainly in Northern England. Excellent staff conditions, pension scheme, etc.

All applications will be treated confidentially but must contain full details of past and current employment, age, education, qualifications and approximate salary required.—BOX No. E8139, "The Engineer."
A

TECHNICAL REPRESENTATIVE (OUTSIDE) wanted for Sheet Metal Machines and Machine Tools. South London and home counties area. Non-contributory pension and assurance scheme.—Write in full to Managing Director, F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1. E8150 A

TECHNICAL SALES

Applications are invited for the appointment of an additional qualified ENGINEER in the Sales Department of an expanding engineering company in S.W. London supplying specialised machinery to the paper and box-making industries throughout the world. Applicants should be between 25 and 32 years of age, possess a degree or H.N.C. in mechanical engineering and have served an apprenticeship.

Previous sales experience is not necessary. The work is responsible and interesting, entailing the discussion of both technical and commercial problems with existing and potential customers and requires outstanding personal qualities.—Applications, with full details of education, qualifications, age and experience, to be sent to BOX No. E8087, "The Engineer."
A

TELEMETRY AND CONTROL ENGINEER

A vacancy occurs with a leading Oil Company for an experienced Engineer with suitable academic and/or professional qualifications.

Applicants should have had design and operational experience of telemetering relating to plant operation, control and instrumentation. A knowledge of V.H.F. multi-channel systems carrier and associated equipment would be advantageous.

The successful candidate would work in London but may be required to travel overseas for short periods. The post carries a non-contributory pension scheme and the salary range is £1000 to £1400 p.a., depending on experience and qualifications.

Write, giving full details of experience and personal particulars, to BOX TE.485, c/o 191, Gresham House, E.C.2. E8105 A

THE PERMUTIT COMPANY LTD.

invite applications from a SENIOR MECHANICAL DESIGN DRAUGHTSMAN, with experience in design of hydraulic control equipment,

and a

SENIOR ELECTRICAL DRAUGHTSMAN with experience in design of automatic control circuits and instrumentation.

These are permanent and pensionable positions with a good starting salary. Please apply to :—The Personnel Officer, Permutit House, Gunnersbury Avenue, W.4. E8104 A

TRANSFORMER WINDER FOR AUSTRALIA.—Applications invited for TRANSFORMER WINDER experienced in winding all types of transformer coils. Apprenticeship in transformer field required and knowledge of high voltage work necessary.—Write with full details to BOX No. 3037, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E8078 A

WORK STUDY

A major industrial organisation requires a trained WORK STUDY ENGINEER with 3 to 5 years' experience in medium industry. The successful candidate must be able to work without detailed supervision and should also have some knowledge of mechanical handling. This is an interesting position and prospects are quite bright. Please write, stating full details of age, experience and qualifications.—BOX No. E8113, "The Engineer." A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, "The Engineer." A

SENIOR MECHANICAL ENGINEER

Minimum B.Sc. in Mechanical Engineering, with 10 years' experience in the design and selection of centrifugal and reciprocating compressors and prime movers, refrigeration systems, blowers and ancillaries as applied to compression equipment.

He will be required to originate specifications for all mechanical and ancillary equipment for cryogenic plants, review and recommend equipment from proposal stage, prepare operating instructions and to site inspect for commissioning and to develop prototype designs within the company and with manufacturers.

Apply, Personnel Manager,
AIR PRODUCTS (GB) LTD.,
49/50, Poland Street, London, W.1.

E8110 A

A MACHINE SHOP SUPERVISOR

is required by

TEXACO TRINIDAD INC.,

for service in Trinidad, W.I.

Applicants must have served a full apprenticeship in heavy engineering and reached Foreman, or at least Section Leader stage. They should have long continuous experience of jobbing shop practice, including sheet metal work, welded fabrications, blacksmithing and heat treatment and should also have a knowledge of work planning and rate fixing. Technical education must be at least to the level of Ordinary National Certificate in Mechanical Engineering.

The starting salary for this pensionable position is in the region of £1300 p.a., and subsidised accommodation and schooling for children will be available.

Please write with brief particulars to the :
Personnel Officer,
TRINOIL (U.K.), LIMITED,
29/30, Old Burlington Street, London, W.1.

E8146 A

THE GARRARD ENGINEERING AND MANUFACTURING CO., LIMITED,

are desirous of obtaining the services of a

DESIGN ENGINEER

Applications are invited from YOUNG ENGINEERS who :

(i) have served an engineering apprenticeship.

(ii) have obtained at least Ordinary National Certificate, Engineering.

(iii) have at least two years' drawing office experience on the design of Small Mechanisms.

The Company are engaged on work of a light Electro Mechanical Nature and the successful applicant will have the opportunity of following his work through from drawing board to Production Line.

The Company consider their staff conditions to be good and operate a non-contributory pension scheme. Assistance with housing can be given if required.

Applications in confidence should be addressed to :

THE CHIEF PERSONNEL OFFICER,
THE GARRARD ENGINEERING AND MANUFACTURING CO., LIMITED,
Newcastle Street,
SWINDON, WILTSHIRE.

E8024 A

PROJECT ENGINEERS

required by Company engaged in the engineering, manufacturing and erection of low temperature process plants.

Applicant must hold Degree or its equivalent in Chemical or Mechanical Engineering, have two years' experience of Project Engineering and three years in the Chemical Process or Allied Industries.

Write : Personnel Manager,
AIR PRODUCTS (GB), LTD.,
49/50, Poland Street,
London, W.1.

E8109 A

JOHNSON, MATTHEY & CO., LIMITED

DESIGN ENGINEER

Aged 23-33, with good drawing-office background, is required for the Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential.

The work entails handling projects from the drawing-board through to construction and running in for production.

Conditions of service include free lunches and an annual bonus, also a contributory pension scheme. Salary according to age, qualifications and experience.

Write, giving full details of age, qualifications, experience, &c., to the Secretary, Johnson, Matthey & Co., Limited, 78, Hatton Garden, London, E.C.1.

E8030 A

FORD

require a

PRODUCT ASSISTANT

Applicants must have :

★ Technical engineering experience and be capable of reading engineering drawings.

★ A lively interest and knowledge of competitive car and truck designs and the ability to argue their technical points with designers.

★ A sound knowledge of the composition of costs and an unusually keen product interest.

If you match up to these requirements and are keen to join an ambitious and expanding organisation, please send full details of age, experience, qualifications and salary requirements to Mr. H. G. Pearman, Training and Recruitment Department, Ford Motor Company Limited, Dagenham, Essex, quoting reference APA.

E8101 A

ENGINEERS . . . . .

Applications are invited for the following positions by a major contracting organisation engaged on the mechanical and civil engineering design and construction of large-scale Oil Refineries, Chemical and Petrochemical plants.

PROJECT ENGINEER

who will be responsible for the co-ordination of specialist design groups and liaison with clients. Applicants should already be in a similar position and hold either A.M.I.Mech.E. or A.M.I.Chem.E.

Commencing salary £2000 p.a.

SENIOR PIPING ENGINEER

experienced in the preparation of specifications, requisitioning and engineering analysis and fully conversant with British and American standards and codes of practice.

Commencing salary £2500 p.a.

VESSEL ENGINEER

must hold A.M.I.Mech.E. and be thoroughly familiar with British and American specifications and codes of practice, basic design, works and field fabrication and engineering analysis.

Commencing salary £2000 p.a.

CIVIL DESIGN ENGINEER

must have had at least 8 years' experience, preferably including at least 3 years in a contracting company.

Commencing salary up to £2000 p.a.
according to experience.

CIVIL (SITE) ENGINEER

required for the supervision of civil engineering work on large oil Refinery and Chemical plant construction sites. Must have had at least 10-15 years' sound experience.

Commencing salary £1500 p.a.

Please write, giving full details, in confidence.—BOX No. E8143, "The Engineer."
A

SITUATIONS VACANT

CHEMICAL ENGINEER

Applications are invited for a position in the Development and Research Department from Associate Members of the Institute of Chemical Engineers or persons holding an equivalent University qualification. Candidates should be under 30 years of age and experience of development work in the heavy chemical industry would be an advantage. Assistance will be given towards housing and removal expenses and a commencing salary of £700–£900 per annum is envisaged to a suitably qualified person. Please send full details in writing to the Secretary, West Norfolk Fertilisers, King's Lynn, Norfolk.

E8092 A

SITUATIONS VACANT

QUALIFIED SALES ENGINEERS WANTED

in various areas to represent Machine Tool Manufacturers and Importers of special high quality equipment. Age 30 to 40. Previous experience essential. Salary according to qualifications and experience. Very good prospects for right applicants.

Apply BOX No. E2645, "The Engineer."

A

SITUATIONS VACANT

PRESSED STEEL COMPANY LIMITED

The Company is engaged in large-scale manufacture of Motor Car Bodies, Commercial, Domestic and Industrial Refrigeration Plant and Railway Rolling Stock and employs some 20,000 in Plants at Oxford, Swindon, Reading and Paisley. In order to meet a continuously expanding Design and Development Programme, applications are invited for appointments as :—

FACTORY PLANNING ENGINEERS

Candidates should be well qualified technically, with considerable experience covering all aspects of Plant, Building and Machinery and in particular in the Shop loading of Plant and Machinery.

These appointments offer the opportunity for those with experience in the above-mentioned capacity to join an expanding Organisation. Conditions of employment accord with best industrial practice. Applications, with full details of education, training, experience and salaries earned, may be made to the Staff Officer, Pressed Steel Company Limited, Cowley, Oxford, where the successful applicants will be located.

E8124 A

SITUATIONS VACANT

MSL *have been retained to advise on the appointment of an*

ASSISTANT WORKS MANAGER

for the structural works of a company manufacturing a variety of heavy steel buildings, bridges and docks equipment. The company, founded over 80 years ago, employs about 2,000 on current major projects.

The Assistant Works Manager will be responsible to, and will deputise for, the Works Manager in the control of production, programming and inspection within the structural works with 500 employees, and in its general administration. Candidates must be qualified structural or civil engineers with experience of heavy steel fabrication and welding.

Preferred age about 35 years. Initial salary not less than £1,500 with pension, life assurance and bonus schemes. Assistance with removal expenses and housing may be arranged.

Please send brief details in confidence, quoting reference G.1932, to J. G. Smith. In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
212, West Regent Street, Glasgow, C.2.

E134 A

BCL

A DEPUTY DEVELOPMENT ENGINEER

is required by

BRITISH CELLOPHANE LIMITED

Applications are invited from Engineers with good Honours degrees who have completed a post-graduate apprenticeship and have had some years' industrial experience, preferably in the sphere of design of process plant, services and auxiliary equipment. The successful applicant will be responsible to the Development Engineer for the work of an extensive team engaged on the design and development of continuous process plant and services. The duties include preparation of projects and estimates, and commissioning of plant, with later investigation of performance of plant and equipment.

The position is one of responsibility and requires a man in the age group 30–40, with initiative and ideas, who is fully conversant with present-day workshop techniques and materials of construction.

Applications, including brief details of qualifications, experience and date of birth, should be addressed to :—

The Personnel Officer,
Bath Road, Bridgwater, Somerset.

E809 A

DESIGN ENGINEER

required by British Jeffrey-Diamond Limited, Wakefield, with wide experience of Hydraulic circuits and control mechanisms, Pumps, Motors, Valves, etc. This is an important appointment with a long-established Company of good standing and prospects are outstandingly good for a man having the necessary practical and technical knowledge and experience.

Applications, giving full details of age, experience and technical qualifications should be addressed to the Secretary.

E8121 A

SENIOR DRAUGHTSMEN

experienced in bulk mechanical handling or foundry work. Superannuation Scheme. Five-day week. Apply to MARCO CONVEYOR & ENGINEERING COMPANY Ltd., 42, George Road, Edgbaston. Birmingham, 15. Edgbaston 4980.

E8020 A

ELECTRICAL ENGINEER

wanted by leading German manufacturer for German-English translations. Applications are invited from British-trained engineers with a good general education and sound technical training, preferably also with practical experience in the application of electric equipment. Good working knowledge of German is essential. The ability to write clearly and concisely will be expected of candidates. A five-day week is worked with generous holidays. Favourable housing conditions for permanent staff.—Apply, stating age, education, qualifications, experience and salary required, —BOX No. E8059, "The Engineer."

A

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Applications are invited for the following appointments in the

RESEARCH TEAM LOCATED AT LITTLEBROOK POWER STATION, DARTFORD, KENT.

The team is developing an advanced steam cycle for power generation employing steam at 1400°F as the working fluid for a "gas" turbine as proposed by J. F. Field (Proceedings, I.Mech.E., V. 162, P. 209, 1950 refer). A portion of the steam is bled from the "gas" turbine circuit and passed through a condensing turbine before re-entry into the primary circuit. The cycle, which contains many unorthodox features and presents many exciting problems, could conceivably be operated with coal, oil or nuclear fuel and provides an opportunity to gain experience in many aspects of power generation.

A superheater with steam capacity of 100 k.lb. per hour is nearing completion and a 15MW pilot plant is planned.

MECHANICAL ENGINEER

The mechanical engineer should be capable of directing a team working on steam cycle analysis and thermodynamic studies relating to both the superheater and the pilot plant.

Candidates should preferably hold a good honours degree with several years' experience with steam plant and have a lively interest in thermodynamics and the theoretical aspects of steam engineering.

The salary will be on a scale within the range £1590–£2045 p.a., according to duties and responsibilities.

ENGINEERS, PHYSICISTS, MATHEMATICIANS

A programme of both theoretical and experimental work is envisaged and successful candidates will assist in running the experimental steam superheater and in the design and subsequent operation of 15MW pilot generating plant mentioned above. They will also be required to study problems involving one or more of the following :—

The thermodynamics and aerodynamics of steam and gas turbines and axial flow compressors, radiant and convective heat transfer, combustion technology associated with P.F. and oil-firing, corrosion resistance and high temperature metallurgy.

Candidates should preferably have an honours degree, with a strong inclination for research and development work.

Salaries will be on scales within a range rising to £1,350 p.a., according to duties and responsibilities. Promotion prospects are good in an expanding organisation.

Applications, stating age, qualifications, experience, present position and salary, should be forwarded to the Personnel Officer, 24 30, Holborn, London, E.C.1, by 18th December. Envelopes should be marked "Confidential Ref. ENR 459."

Candidates who are interested and would like to have further preliminary information about these posts are invited to telephone Chancery 2866, Ext. 30.

E8093 A

CRANE DESIGNER

A prominent crane building company in the Glasgow area have a vacancy for

A MODERN CRANE DESIGNER

Applicants should state experience in this class of work, and educational certificates held. Good working conditions. Contributory Pension and Free Life Insurance Scheme. Salary commensurate with experience and ability. State when free to start.—BOX No. E8118, "The Engineer."

A

Classified Advts. continued on page 146

SITUATIONS VACANT

AUTOMATION OF FORGING

is being pioneered on a pilot-scale plant of the British Iron and Steel Research Association in Sheffield. A graduate in mechanical engineering is required to further this development in collaboration with a forging technologist and an electrical control engineer. Duties will involve liaison with leading makers of heavy engineering equipment who are backing the project. This is an opening of great scope for a young man with a creative mind, sound technical background, and the ambition to move quickly ahead in development engineering. The post commands a good starting salary with superannuation, and prospects of rapid advancement by merit.—Written applications only, outlining education and experience, and quoting "M.W.14" to the Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1.

E8076 A

SITUATIONS VACANT

LEADING MANUFACTURERS OF CENTRIFUGAL PUMPS

invites

Applications from suitably qualified Engineers to fill the following appointments:

TEST SUPERINTENDENT to take full charge of test stand dealing with a wide range of centrifugal pumps driven by A.C. and D.C. motors, diesel engines and steam turbines. Applicants must have had a sound technical and practical training and technical education up to H.N.C. standard or equal, and previous experience in a similar capacity.

ENGINEER ASSISTANT IN THE TECHNICAL DEPARTMENT to work in close collaboration with the Test Superintendent. He will be required to check and analyse test results, issue instruction for modification needed on test, and keep Sales, Estimating and other Technical Departments posted with essential information regarding pump characteristics. To do this he must have knowledge of the design and performance of all types of centrifugal pumps. Technical Education up to H.N.C. standard.

Applicants should preferably be aged between 30–40 years, and are asked to write, giving particulars of education, training and experience to BOX No. E8075, "The Engineer." A

SITUATIONS VACANT

CHIEF MECHANICAL ENGINEER

(Designate)

for an old-established firm of lift manufacturers located in the North-West, to act firstly as Technical Assistant to the Board and then gradually to assume the duties and responsibilities of Chief Mechanical Engineer. Commencing salary not less than £1250 p.a., substantial bonus, pension scheme, etc., with appropriate increase on appointment as Chief Mechanical Engineer. Subsequent progress will depend on merit, but there are good promotional and financial prospects. Preferred age about 35.

As Technical Assistant to the Board, the incumbent will be responsible to the Executive Director and his principal duties will be to familiarise himself with the Company's products, methods, problems, etc., with special reference to design, estimating and sales, with the object of taking over full responsibility as Chief Mechanical Engineer as soon as possible. As Chief Mechanica Engineer he will be a senior executive of the Company and will be in charge of the mechanical drawing-office and the estimating and sales departments.

Qualifications required are sound, practical mechanical engineering background (preferably A.M.I.Mech.E.), with good drawing-office and estimating experience plus a knowledge of light steel construction and the ability to control staff including a small technical sales force. Some general knowledge of concreting, brickwork and "fixing" problems would be of advantage, as would previous experience of the lift industry.

Please write briefly in first instance, quoting Reference No. 283, to :—

AA LTD.

ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1
retained to advise on this appointment

The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

E8096 A

SITUATIONS VACANT

STANDARDS ENGINEER

Graduate H.N.C. (Mech.) minimum, with 3 years' experience as a Standards Engineer in the Chemical and Process Plant Industry. To originate and prepare engineering standards for use in the Design Department and other engineering facilities of the Company on request and to develop these standards into a comprehensive manual on his own initiative. Must be able to develop fully design standards for all aspects of pressure vessel, piping and mechanical design for ferrous and non-ferrous applications. Experience of high pressure and high temperature systems is necessary, together with an intimate knowledge of all valves and flange systems. Must possess leadership potential to develop a fully integrated Standards Group.

Write Personnel Manager,
AIR PRODUCTS (G.B.), LTD.,
49/50, Poland Street, W.1.

E8111 A

TO AMBITIOUS PRODUCTION MANAGERS

A worldwide group with expanding organisation must recruit an experienced young PRODUCTION MANAGER of about 30 at up to £2000 p.a. Early promotion and remuneration, rising to the £3500–£4500 bracket. The scope and diversity of this management position are unique. A university graduate is preferred.

Please send short outline of age, education, experience and present salary to BOX No. E8088, "The Engineer."

A

AN ASSISTANT CHIEF ENGINEER

is required for a medium-heavy engineering works employing some 1400 persons. Applicants must have an Engineering degree or parallel qualifications in electrical or mechanical engineering and should preferably be Corporate Members of the appropriate Institution. As the successful candidate will have to take immediate control of a large maintenance organisation, it follows that only men with the requisite practical experience and authority of manner will be considered. A professional engineer of exceptional ability and personality is sought as it is essential that he should be able to develop well beyond the requirements of the present post in the relatively near future. The Company offers excellent conditions of employment, including a Pension and Life Assurance scheme.

Please write, giving full particulars of age, experience, qualifications, etc., to Managing Director, TUBES LIMITED, Rocky Lane, Aston, Birmingham, 6, marking envelope A.C.E.

E8122 A

SMITHS

offer excellent career potential for responsible men

DESIGNERS

Help us to Design for the Motor Industry.

We require men with new ideas and a natural urge to Design in the ever-widening and exciting field of mass produced instruments and light mechanisms.

Suitable persons will have been engaged in design work continuously for at least the past five years in the light precision engineering industry.

An apprenticeship or equivalent is necessary, together with the essential qualification of H.N.C.

SENIOR DRAUGHTSMEN

Our London Production Offices require Senior Draughtsmen with experience of precision instruments or small mechanisms for mass production. Suitable applicants must be qualified to at least H.N.C. standard. A knowledge of press work would be an advantage.

DEVELOPMENT ENGINEERS

This interesting and responsible post occurs in the Product Development Department of the Motor Accessory Division, and is available to men who have had at least the past five years' continuous experience in the development of precision mechanisms for mass produced instruments.

An H.N.C. in Mechanical Engineering would be a suitable qualification, although A.M.I.Mech.E. would be preferred. An apprenticeship or equivalent training in workshops is essential.

Assistant PROVING ENGINEER

For this post it is necessary to have had at least four years' experience with small electrical and mechanical instruments, together with associated equipment. Suitable candidate would be between 25/30 years of age, and be qualified to at least O.N.C. standard.

Assistant CHIEF INSPECTOR

We are seeking an Inspector, knowledgeable in modern inspection techniques, who, with confidence, will be able to control a strong inspection team.

He should have been trained as a craftsman, have had Quality Control experience and be conversant with gauge and tool design. Preferably he would have been associated with the large-scale production of components, including die-castings and small pressings, also with the assembly of small mechanisms.

Ability to report lucidly both verbally and in writing is essential.

Applicants, who should be qualified to H.N.C. standard in Mechanical Engineering, will have served an apprenticeship and progressed through workshops and drawing-offices, and to be at present in receipt of a four-figure salary.

The appointment will carry with it consideration for the post of Chief Inspector within the next few years.

These Posts are Available in the New Year and Interviews will be arranged immediately. *Write in confidence to:*

The Staff Manager, quoting ref: SM/238,

S. SMITH & SONS (ENGLAND) LIMITED, CRICKLEWOOD, LONDON, N.W.2.

A8120 A

SITUATIONS VACANT

BROWN & POLSON, LTD.

PROJECT ENGINEERING

Due to a continuing expansion programme an opening is available for a Project Engineer to work on Chemical Process Plants, manufacturing Starch, Glucose, and a variety of starch derivatives. Attractive salary and employee benefits

— if you are —

1. Under 35.
2. Have had experience on design or installation of equipment for handling solids or liquid materials.
3. Hold a degree in Chemical/Mechanical Engineering.
4. Have the capacity to handle projects effectively from flow sheet to installation.

Send detailed application now to

Personnel Adviser,
Brown & Polson, Ltd.,
Trafford Park, Manchester, 17

E8068 A

SITUATIONS VACANT

ENGINEER

required to prepare operating and maintenance instructions for condensing and feed heating plants for power stations and marine closed feed systems. He would also be required to attend official tests, sea trials, and to be present during commissioning periods. This important appointment calls for sound technical training to at least Higher National Certificate level, adequate operating experience, and a good command of English. Successful applicant must possess initiative and the ability to work with the minimum of supervision.

Applications should be marked "Confidential" and addressed to The Technical Director, Worthington-Simpson, Ltd., P.O. Box 17, Newark, Notts.

E8026 A

SITUATIONS VACANT

LARGE CONTRACTING CONCERN

of international repute intends to appoint a

DRILLING SUPERINTENDENT

for overseas projects. Ability to organise and control Well drilling and development programme. Must be experienced in reverse circulation rigs.

Attractive financial arrangements. Excellent prospects. Ability to leave U.K. immediately essential. No married accommodation on initial tour.

Write full details of age, experience and qualifications to BOX No. DL.7063, c/o Whites, 72, Fleet Street, London, E.C.4.

E8125 A

SITUATIONS VACANT

W. H. ALLEN SONS & CO., LTD., QUEEN'S ENGINEERING WORKS, BEDFORD,

require at their

LEAMINGTON SPA BRANCH OFFICE

A

QUALIFIED ENGINEER

aged 25–35, as a TECHNICAL SALES REPRESENTATIVE in connection with Power and Pumping Plant comprising Steam Turbines, Diesel Engines, Gearing, Pumps.

This appointment would necessitate residence at Leamington Spa and give the opportunity for considerable travel.

Generous Pension Scheme and holidays.

Apply, stating qualifications, experience and present salary, to the Personnel Manager (Ref. 829/202).

E8123 A

MECHANICAL, INSTRUMENT AND ELECTRICAL ENGINEERS

COURTAULDS requires qualified Mechanical, Instrument and Electrical Engineers, aged 25 to 40, for important work in design, construction and maintenance of large synthetic fibre and chemical plants. Preference will be given to candidates who have a good Honours Degree in Mechanical or Electrical Engineering, and, for the junior appointments, to those who have already completed a suitable apprenticeship and had two or more years' experience in the design or maintenance of industrial plant.

The vacancies are additional permanent appointments with opportunities for obtaining a wide experience in the process engineering and contracting fields and prospects of promotion for men with an original approach to problems are excellent. The work is exceptionally varied, covering the complete range of engineering activities from heavy industrial equipment to fine mechanisms and highly specialised machinery of Courtaulds' own design, and including boiler and power plant and distribution of services.

Successful candidates will be given the necessary background knowledge of the various processes concerned to enable them to further the development of modern manufacturing techniques and automatic control in the industry.

Financial assistance is normally awarded to married men when moving house. The appointments are pensionable and the occupants will be eligible for Co-partnership benefits.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16, St. Martin's-le-Grand, London, E.C.1, quoting reference number B.55.

E8126 A

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

announces the setting-up of a

CONSULTATION SERVICE

If you are an experienced scientist or engineer and think that you may be interested in a senior post (salary from £3000 upwards) with the United Kingdom Atomic Energy Authority, you can learn more about the opportunities available without committing yourself to making a formal application for a post.

Arrangements can be made for an

Informal and confidential interview

by telephoning or writing to Mr. H. S. Hoff, Personnel Consultant, U.K.A.E.A., 11, Charles II Street, London, S.W.1. (Whitehall 6262.)

The more relevant detail about yourself that you can supply in advance—qualifications, experience, age, &c.—the better.

The interview will be entirely confidential : after it no further action whatsoever will be taken by the Authority unless you specifically request it.

E8000 A

PROJECT MANAGER

An International Company engaged in the Design, Procurement, and Construction of major Oil Refinery and Chemical plants requires a senior man to take control of multi million pound projects.

Applicants should already be in a similar position, and should hold either A.M.I.Mech.E. or A.M.I.Chem.E.

Commencing salary in the region of £3,000 per annum, with the normal benefits of a well-established Company.

Please write, giving fullest particulars of age and experience, &c., to : BOX No. E8077, "The Engineer."

A

PRESSED STEEL COMPANY LIMITED

The Company is engaged in large-scale manufacture of Motor Car Bodies, Commercial, Domestic and Industrial Refrigeration Plant and Railway Rolling Stock, and employs some 20,000 in Plants at Oxford, Swindon, Reading and Paisley. In order to meet a continuously expanding programme, applications are invited for appointments as :

JIG AND TOOL DESIGNERS

to be located at Oxford, Swindon and Paisley.

Candidates should already be qualified Jig and Tool Designers with considerable experience in the design of press tools for Car Body Manufacture.

These appointments offer the opportunity for those well-qualified technically, with experience in the above-mentioned capacity, to join an expanding Organisation. Conditions of employment accord with best industrial practice. Applications, with full details of education, training, experience and salaries earned, may be made to the Staff Officer, Cowley, Oxford, quoting location sought.

E8080 A

ENGINEER

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, WOOLWICH COMMON, S.E.18

To develop and advise on the use of plastics in the production of electronic and high-voltage electro-mechanical equipment. To investigate and develop new production techniques.

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SALARY : £1445–£1900, including London Allowance.

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E8074 A

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Wish to appoint a professional engineer to lead a project associated with

LARGE INDUSTRIAL GAS TURBINES

The responsibilities and scope of the project are likely to be attractive to a man aged 30–35 who has a good Honours Degree in Mechanical Engineering and some design or development experience of high-speed rotating machinery. Men under 30 years of age will certainly be considered if they have had some suitable industrial or research experience.

Please write, giving details of education and experience, to The Chief Engineer, Gas Turbine Division, c/o Dept. C.P.S., Marconi House, Strand, London, W.C.2, quoting reference E1909K.

E8090 A

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GRADUATE I.MECH.ENG. (34), with wide experience in medium and heavy industry, analytical work, design, supervision, seeks responsible position. —BOX No. E2648, "The Engineer." B

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REPRESENTATION.—Firm of Engineering Agents with offices in Glasgow require additional Agency. Excellent connection with industries throughout Scotland and particularly with Metal Working and Finishing Industries.—BOX No. E8127, "The Engineer." D

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Classified Advts. continued on page 148

BUSINESS OPPORTUNITIES

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25–28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 o

WOULD £5000 HELP YOU TO GET AHEAD?

£5000 is the main prize in the new Get Ahead contest organised by the *News Chronicle*. The B.B.C. will televise eight heats and the final. You need not have your own business to qualify for the final. All finalists will win considerably more than £200. In all, £7500 will be won. Anyone with a sound business idea for putting £5000 to good use should write for details *now* to: Get Ahead, *News Chronicle*, 4/7, Lombard Lane, London, E.C.4.

E7991 o

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LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. E103 K

MISCELLANEOUS

TIME RECORDERS. Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157–159, Borough High Street, London, S.E.1. E110 I

PATENTS

THE PROPRIETOR of British Patent No. 715619, entitled "METAL WORKING MACHINES AND OPTICAL PROJECTION APPARATUS THEREFOR," offers same for License or otherwise to ensure practical working in Great Britain.—Enquiries to Singer, Stern and Carlberg, 14, E. Jackson Blvd., Chicago 4, Illinois, U.S.A. E8054 H

MACHINERY &c. WANTED

WANTED: Crane on own chassis or lorry-mounted. All types up to 8 tons considered.—BOX No. E7917, "The Engineer." F

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Fielding 500-ton Vertical Downstroke Hydraulic Press, 42in. by 36in. platens, with pumps and motors.
Fielding 200-ton ditto, 3ft. stroke, with pumps and motors (5 available).
Fielding 100-ton ditto, 4ft. to 5ft. stroke, with pumps and motors.
Two 73ft. 4in. by 4ft. Brick Lined Kilns or Dryers, with Crofts reduction gears and motors.
Two 26ft. by 4ft. Rotary Cooler or Dryers, with reduction gear and motor.

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600

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Unused 979kVA., 6·6kV, 3-phase, 50 cycles Diesel Engine Driven Alternator Set, incorporating engine by MIRRLEES BICKERTON & DAY, type JV.16, 1120 h.p. at 750 r.p.m., 16-cylinder, direct-coupled to alternator by Brush Electrical revolving field, mounted on soleplates with direct-coupled exciter, engine complete with standard ancillaries, alternator with switchboard by Reyrolle with automatic voltage regulator.
500kW. continuous 24-hour duty, 380/440 volts, 3-phase, 50 cycles, Diesel Engine Driven Alternator Set, direct-coupled at 375 r.p.m. and comprising 750 h.p. BELLISS & MORCOM 7-cylinder vertical engine, complete with ancillaries, starting equipment, direct-coupled to alternator by Lancashire Dynamo Co., complete with switchgear.
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240kVA., 400/440 volts, 3-phase, 50 cycles, 4-wire, Diesel Engine Driven Alternator Set, direct-coupled at 600 r.p.m. and comprising engine by DAVEY PAXMAN, type 5RPL, 5-cylinder, direct-coupled to alternator by Metropolitan-Vickers, with direct-coupled exciter and complete with switchgear.

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BESCO Double Geared Hand Operated Universal Swing Beam Folding Machine, capacity 6ft. 2in. by ¼in. thick, smallest trunk round beam 8¼in. by 7¼in.
BESCO Size No. 12 Slip Roll type R, 80¼in. by 3¼in., Hand or Power Operated Geared Bending Roller, hand operated friction drive for forward or reverse motion, the top roller swings out to enable cylinders to be withdrawn, capacity in mild steel 12 S.W.G.
WESTON Model 400/100 Double Sided Friction Screw Press of welded steel plate construction, arranged motor drive for 400/3/50, pressure exerted approximately 120 tons, maximum stroke 11in., diameter of screw with four starts 6¼in., weight approximately 5 tons 8 cwt.
NEW BRUECK Type 20/1600, All-Steel Motorised Press Brake, geared steel plate construction, arranged motor drive for 400/440/3/50, maximum pressure exerted 20 tons, former capacity 63in. by ¼in.
NEW MUBEA All-Steel Construction Bar and Angle Shear, enclosed flywheel and gears, motorised for 400/3/50, Model KSG.100; capacity: round and square bars 2in., flat iron 10in. by ¾in., 5¼in. by 1in., angles up to 4in. by ¼in., 5in. by 0·425in., tee iron 5in., beams 6in., channels 6in., length of blades 12¼in.
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Photographs of the above are available.

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200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
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MOBILE ROAD CRANES.—10-ton Lorain lorry-mounted 30ft.–70ft. extendible jib; 10-ton 33 R.B. track mounted, 40ft. jib; 8½-ton Ransomes Diesel/Electric, 21ft. jib. 6-ton Coles Diesel/Electric, pneumatics, new 1948 (2); 6-ton Coles Diesel/Electric, solids; 4-ton Coles Diesel/Electric, solids; 1945; 4-ton Jones KL44, diesel, 1950; 3-ton Jones "Super 40" diesel, pneumatics (3).
OVERHEAD CRANES.—20/6-ton Vaughan 42ft. 3in. span, cab type (6); 20-ton King, 42ft. 3in. span, 400/3/50; 15-ton Booth, 37ft. span, 400/3/50; 15-ton Morris, 35ft. span, hand-operated; 10-ton Morris, 48ft. span, 36ft. lift; 10-ton Morris "Goliath," 40ft. span, 400/3/50; 10-ton Vaughan, 23ft. 6in. span, 400/3/50; 10-ton Vaughan, 21ft. span, 44ft. lift; Wharton 7½-ton, 25ft. span, 400/3/50; 5-ton Henderson, 24ft. 7in. span, 1946; 5-ton Morris, 58ft. span, hand-operated; 5-ton Royce, 2-motor crab, 440/3/50; 5-ton King, 29ft. 3in. span, power hoist, hand travel; 5-ton Morris, 28ft. 6in. span, power hoist, hand travel; 4-ton Morris, 19ft. span, 220V, d.c. (3); 3-ton Adamson, 48ft. span, 400/3/50; 2-ton Adamson, 34ft. span, 400/3/50 (2); 2-ton Morris, 18ft. span; 2-ton Vaughan, 27ft. 6in. span, 2-motor; majority of the above are unused.
DERRICK CRANES.—7-ton Rushworth, hand, 30ft. jib; 5-ton Wilson, electric, 70ft. jib; 1½-ton Anderson Grice, hand, 40ft. jib.
RAIL CRANES.—18-ton Brownhoist, steam, 50ft. jib; 10-ton Coles, steam, 40ft. jib; 10-ton Grafton 34ft. jib, diesel conversion; 8-ton Wilson, steam, 35ft. jib; 5-ton Grafton, 35ft. jib, diesel conversion; 5-ton Smith, 50ft. jib (2); 5-ton Cowans Sheldon, 50ft. jib.
LOCOS.—Fowler diesel, 150 h.p. (2); Barclay & Ruston 80/88 h.p. diesel; Bagnall 14in. by 22in. (two oil-fired, one coal), Peckett, steam, 7in. by 12in., 1941; also 3 miles track, 24in. gauge, Bogies, Turnouts, &c.
STEEL PIPING.—50,000ft., 2in. Galvanised, new; 60,000ft., 3in. black, new; 5000ft., 8in. seamless; 1000ft., 12in. seamless; 500ft., 14in. seamless; 400ft., 18in. riveted; 280ft., 21in. o.d. welded flanged; 3800ft., 21in. seamless flanged; 500ft. 24in. riveted; 1450ft., 27in. o.d. welded flanged; 216ft., 48in. riveted; 216ft., 60in. riveted.
CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.
VALVES.—Exceptional Surplus Ministry Lot. New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock all sizes, Parallel Slide Sluices, Gunmetal, Reducing and Check Valves. List on request.
STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.
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600

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BELLISS & MORCOM Surface Condenser, 8ft. 6in. long by 3ft. 6in. dia., designed for 8400 lb. exhaust steam per hr., maintaining 26in. vacuum when supplied with 29,000 galls. of cooling water per hr. at 75 deg. F. Complete with water circulating and condensate pump.
WORTHINGTON SIMPSON 7500 lb. steam per hr. at a vacuum of 26in. when supplied with 30 g.p.m. of circulating water at 80 deg. F. Complete with combined A.C. motor-driven water circulating and condensate extraction pump.
DAVEY PAXMAN Surface Condenser, 10,000 lb. steam per hr. at 26in. vacuum when supplied with 500 galls. of cooling water per min. at a temperature of 70 deg. F. Complete with water circulating and extraction pump.
BELLISS & MORCOM Condenser, 17,000 lb. steam per hr. at 25in. vacuum when supplied with 43,000 galls. of cooling water per hr. at a temperature of 80 deg. F. Complete with extraction pump and air ejector.

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E8099 G

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E R

By Order of the Secretary of State for War

GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
December 8-9	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, Byley, Nr. Middlewich, Cheshire. (Sale at Cheetham Town Hall, Manchester, 8.)	J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
December 9-11	Vehicles, lifting and earth moving equipment including	M.O.A. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
	240 saloons, limousines, and estate cars by Austin, Ford, Hillman, Humber, Morris, Standard, Vauxhall and Wolseley; Austin "Champs" and Land Rovers; coaches, vans, tippers, and other load carriers and dual purpose vehicles (many fitted with diesel engines); trailers 10 cwts.–16 tons; tankers 200 galls.–2,500 galls.; excavators (rigged crane, face shovel, and back acter) by Koehring and Ruston Bucyrus; mobile cranes (some lorry-mounted) by Bay City, Coles, Cranemobile, Jones; crawler tractors and bulldozers, including D.4's, D.7's, and D.8's by Caterpillar; road rollers; snow ploughs, Clark electric fork lift truck; workshop trailers fitted with lathes, drilling machines, grinders, generating sets, switchboards, etc.; wheeled tractors including unused David Brown "TASKMASTERS"; trailer-mounted fire pumps; dumpers; plant ancillaries and spares by Caterpillar, International, etc.		
December 15	Miscellaneous stores.	General Stores Sub-Depot, Longtown, Nr. Carlisle. (Sale at County Hall, Carlisle.)	HARRISON & HETHERINGTON (Dept. L), Botchergate, Carlisle. (Tel.: 26292.)
December 17-18	Vehicles, machine tools and miscellaneous stores.	M.O.A. Storage Depot, Bowhouse, Hurlford, Nr. Kilmarnock, Ayrshire.	DIXON & WALLACE, LTD. (Dept. L), Bank Buildings, Graham Street Glasgow, E.1. (Tel.: Bridgeton 2447/9.)
1960 January 4-8	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
January 15	Miscellaneous stores.	Returned Stores Group, Reed Hall, Colchester, Essex.	FENN WRIGHT & CO. (Dept. L), 146 High Street Colchester, Essex. (Tel.: 3171.)

Applications for catalogues, available 14 days prior to date of sale, should be made *only* to the auctioneers shown above (price of catalogue 1s. 0d.—P.O. only).

E118 J

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5340 ton Up-Stroking PRESS, 8ft. by 5ft., with Pump Unit.
3000 ton Down-Stroke PRESS, 10ft. 6in. by 8ft.
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E7970 G

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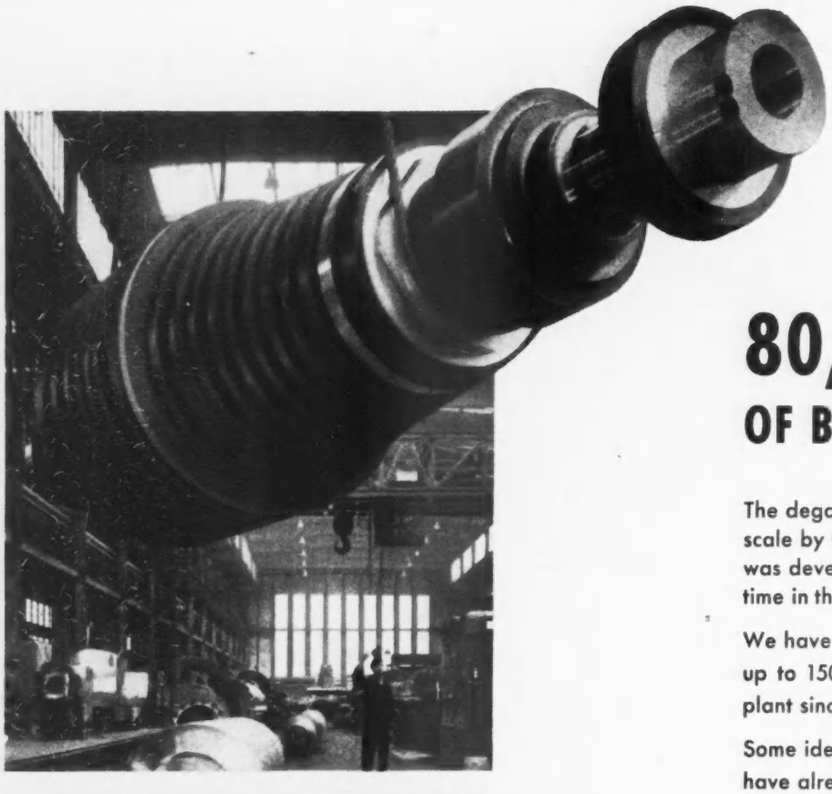

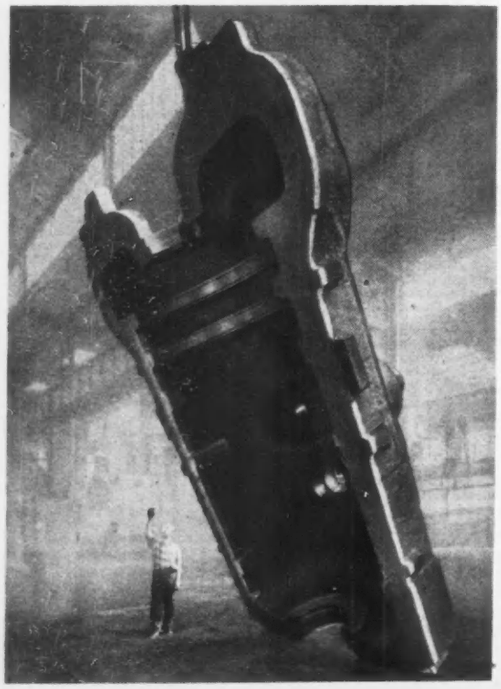

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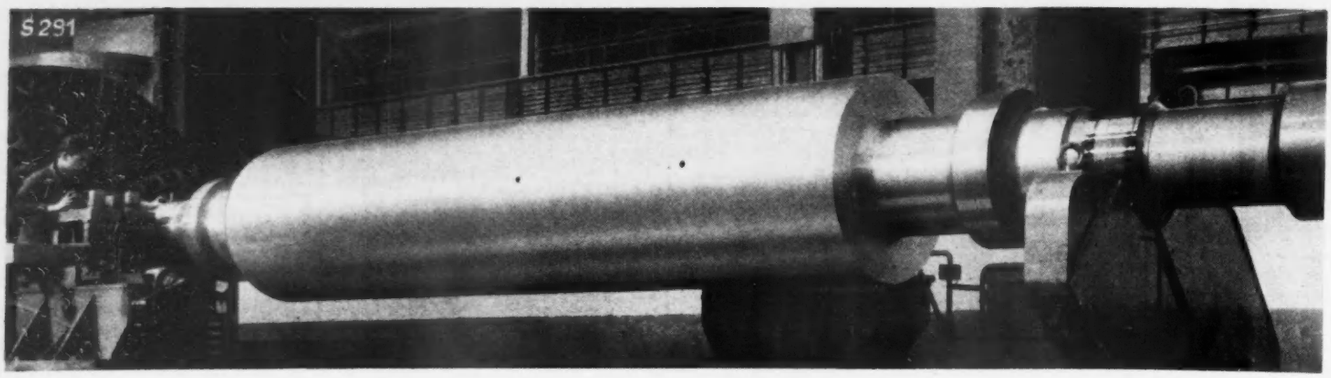

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INDEX TO ADVERTISERS

PAGE

AB Atlas Copco/Sweden Cover ii
A.C.E. Machinery, Ltd. 92
Acheson Colloids, Ltd. 25
Acme Flooring & Paving Co. (1904), Ltd. 6
Adamson, J., & Co., Ltd. 122
Airscrew Co. & Jicwood, Ltd. 152
Allen, W. H., Sons & Co., Ltd. 24
Ambuco, Ltd. 31
Ames Crosta Mills & Co., Ltd. 134
Anderson, C. F., & Son, Ltd. 29
Armstrong Patents Co., Ltd. 39
Army Emergency Reserve 148
Arrol, Sir William, & Co., Ltd. 41
Arup & Arup, Ltd. 119
Ash, J., & Son, Ltd. 25
Ashmore, Benson, Pease & Co., Ltd. 9
Associated Electrical Industries, Ltd. 28-42
Audley Engineering Co., Ltd. 56
Aurora Gearing Co. (Wilmot North), Ltd. 110
Automotive Products Co., Ltd. 77

B.A. Holland Engineering Co., Ltd. 21
BTR Industries, Ltd. 98
Bailey, Sir W. H., & Co., Ltd. 2
Baker, W. A. & Co., Ltd. 57
Barnet Metal Co., Ltd. 15
Barron, W. S., & Son, Ltd. 68
Birmetals, Ltd. 46
Blackwell Bearings, Ltd. 86
Bochumer Verein 150
Booth, J., & Bros. 66
Booth, J., & Co., Ltd. 78
Brightside Foundry & Engineering Co., Ltd. 125
Britannia Iron & Steel Works, Ltd. 88
British Aero Components, Ltd. 83
British Appliances Mfg. Co., Ltd. 110
British Ermeto Corporation, Ltd. 7
British Insulated Callender's Cables, Ltd. 23
British Paints, Ltd. 51
British Ropeway Engineering Co., Ltd. 6
British Steam Specialties, Ltd. 79
Britool 54
Broadbent & Co. (Rochdale), Ltd. 68
Broadwell Engineering, Ltd. 35
Bronx Engineering Co., Ltd. 120
Brookhirst Igranic, Ltd. 64
Broom & Wade, Ltd. 101
Brown, D. (Brownall), Ltd. 88
Brown, D., Corporation (Sales), Ltd. 87
Brown, N. C., Ltd. 69
Brownlie & Murray, Ltd. 131
Budenberg Gauge Co., Ltd. 121
Bullows, A., & Sons, Ltd. 151
Butcher, H., & Co. 149
Butters Bros. & Co., Ltd. 85

C. & M. Engineering Co., Ltd. 131
Caird & Rayner, Ltd. 15
Carborundum Co., Ltd. 8
Carobronze, Ltd. 138
Carter, B. & F., & Co., Ltd. 110
Cascade Water Coolers, Ltd. 36
Caston Barber, Ltd. 38
Ciba (A.R.L.), Ltd. 136
Clayton Crane & Hoist Co., Ltd. 57
Clinton-Wall Publicity, Ltd. 129
Clyde Blowers, Ltd. 35
Clyde Crane & Booth, Ltd. 66
Clyde Crane & Engineering Co. 66
Cohen, G., Sons & Co., Ltd. 137
Colt Ventilation, Ltd. 3
Cowans Sheldon & Co., Ltd. 6
Cowlishaw Walker & Co., Ltd. 128
Crabtree, J. A., & Co., Ltd. 70-71
Crane, Ltd. 121
Crofts (Engineers), Ltd. 72
Crossley-Premier Engines, Ltd. 65
Cross Manufacturing Co. (1938), Ltd. 140
Cull, W. B., & Sons, Ltd. 4

Darlington Forge, Ltd. 62
Donovan Electrical Co., Ltd. 109
Dowty Seals, Ltd. 10

Electrical Power Engineering Co. (B'ham), Ltd. 138
Electromagnets, Ltd. 54
Elliston, Evans & Jackson, Ltd. 122
English Steel Forge & Engineering Corporation, Ltd. 118
Entwisle & Gass, Ltd. 36
Etchells, D. (Furnaces), Ltd. 132
Exprimruch 51

Farmer, L., & Sons 149
Farrar Boilerworks, Ltd. 93
Ferranti, Ltd. 63
Filton, Ltd. 133
Fleming & Ferguson, Ltd. 128
Flexible Ducting, Ltd. 134
Fluxite, Ltd. 67
Foord, J., & Co. 149
Ford Motor Co., Ltd. 47
Fordsmith, H., Ltd. 122
Forster, T. S., & Sons, Ltd. 37
Foyles 75
Fuller, Horsey, Sons & Cassell 149

Gas Council 106-107
General Descaling Co., Ltd. 112
General Electric Co., Ltd. 86
General Refractories, Ltd. 48
Gibson, A. L., & Co., Ltd. 133
Gilbarco, Ltd. 58
Girdlestone Pumps, Ltd. 37
Glacier Metal Co., Ltd. 76
Godfrey, Sir G., & Partners (Ind.), Ltd. 69
Goodwin, R., & Sons (Engineers), Ltd. 140
Greenwich Insulation Co., Ltd. 12
Greenwood's Standard Gear Cutting Co., Ltd. 131
Gregory, J. G., & Son, Ltd. 89
Guest, Keen & Nettlefolds (Midlands), Ltd. 130
Gypsum Plasterboard Development Association 19

Harvey & Longstaffe, Ltd. 18
Harvey, G. A., & Co. (London), Ltd. 82
Harlow, R., & Son, Ltd. 53
Hayward, E., & Co. (Fabrications), Ltd. 88
Herbert, A., Ltd. 21
Hermetic Rubber Co., Ltd. 69
Higgs Motors, Ltd. 40
Hoffmann Manufacturing Co., Ltd. Cover v
Holmes, C. D., & Co., Ltd. 58
Holroyd, J., & Co., Ltd. 27
Holst & Co., Ltd. Cover v
Horseley Group 94
Howden, J., & Co., Ltd. Cover vi
Hughes, J. & J., Ltd. 79
Hughes-Johnson Stampings, Ltd. 22
Hudswell Clarke & Co., Ltd. 110
Hunt Heat Exchangers, Ltd. 75

Imperial Chemical Industries, Ltd., Billingham Division 29
Ince Forge Co., Ltd. 25
International Combustion Products, Ltd. 32

Jellyman, S., Ltd. 97

Kabelschlepp G.m.b.H. 15
Kay & Co. (Engineers), Ltd. 90
Kenyon, W., & Sons, Ltd. 93
Knitmesh, Ltd. 67
Krupp, Fried 11

Lanarkshire Bolt, Ltd. 52
Lancaster & Tonge, Ltd. 97
Leeds & Bradford Boiler Co., Ltd. 138
Leeds Engineering & Hydraulic Co., Ltd. 132
Lethaby, W., & Co., Ltd. 21
Limitorque Valve Controls, Ltd. 47
London Electric Firm, Ltd. 98
Long Meadow Felt Co., Ltd. 127
Lynch, M., & Son, Ltd. 51

Macfarlane Engineering Co., Ltd. 99
MacLellan, P. & W., Ltd. 77
McNeil, C., Ltd. 128
Magnolia Antifriction Metal Co. of Great Britain, Ltd. 51
Markland Scowcroft, Ltd. 37
Marsden, S., & Son, Ltd. 48
Marshall Fleming & Co., Ltd. 110
Martin, Black & Co. (Wire Ropes), Ltd. 111
Maxseal Valves, Ltd. 67
Measurement, Ltd. 117
Meldrum, Flood-Page, Ltd. 67
Mercedes Benz 139
Metallic Valve Co., Ltd. 97
Micanite & Insulators Co., Ltd. 57
Midland Heating & Ventilation Co., Ltd. 55
Mobil Oil Co., Ltd. 45
Mond Nickel Co., Ltd. 73
Montgomerie Stobo and Co., Ltd. 13
Morgan Liftways & Powerways 138
Morgan Refractories, Ltd. 50
Morris, H., Ltd. 113
Moss Gear Co., Ltd. Cover i
Mountford, J., & Co., Ltd. 75

Neco Geared Motors, Ltd. 4
Newbury Diesel Co., Ltd. 131
Newton Sales Co., Ltd. 59
Norris Bros., Ltd. 25
North British Locomotive Co., Ltd. 105

Parker, F., Ltd. 119
Patent Lightning Crusher Co., Ltd. 68
Payne & Griffiths, Ltd. 52
Peglers, Ltd. 108
Perry Engineering, Ltd. 126
Petters, Ltd. 124
Phillips, B. L. & N., Ltd. 94
Pilot Works, Ltd. 104
Pinchin, Johnson & Co. 53
Pitman, Sir Isaac, & Sons, Ltd. 143
Pittam, J., & Co. 116
Plenty & Son, Ltd. 5
Pool, J. & F., Ltd. 18
Positive Lock Washer Co., Ltd. 35
Precision Rubbers, Ltd. 121
Prestons, Ltd. 59
Priest Furnaces, Ltd. 35

Qualter Hall & Co., Ltd. 102

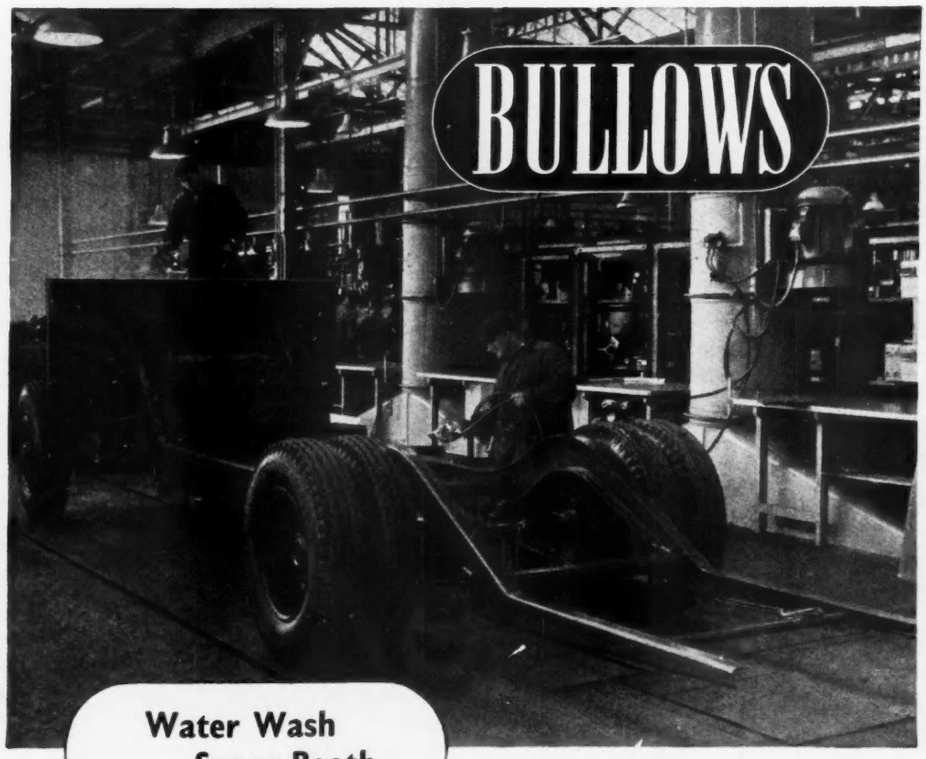
Railko, Ltd. 30
Ratcliffe, F. S. (Rochdale), Ltd. 89
Reed Crane & Hoist Co., Ltd. 10
Renold Chains, Ltd. 114-115
Reyrolle, A., & Co., Ltd. 100
Rocol, Ltd. 123
Round Oak Steel Works, Ltd. 34
Rubber By-Products (Warwickshire), Ltd. 25
Russ-Elektroofen, K.G. 95
Ruston-Bucyrus, Ltd. 135

Salisbury Transmission, Ltd. 20
Saunders Valve Co., Ltd. 76
Savery, T., Pumps, Ltd. 81
Schieldrop & Co., Ltd. 48
Schiess A.G. 43
Scriven Machine Tools, Ltd. 122
Sealdraught, Ltd. 89
Selson Machine Tool Co., Ltd. 75
Semtex, Ltd. 96
Shipham & Co., Ltd. 26
Slingsby, W., & Co., Ltd. 79
Small, W. H., Ltd. 48
Smedley Bros., Ltd. 18
Smith & McLean, Ltd. 108
Staedtler, J. S., Ltd. 81
Stahl-und Röhrenwerk Reisholz G.m.b.H. 103
Stainless Steel Wire Co., Ltd. 79
Standard Piston Ring & Engineering Co., Ltd. 108
Stanley, W. F., & Co., Ltd. 26
Steel Construction Co., Ltd. 38
Steel Stampings, Ltd. 140
Steels Engineering Installations, Ltd. 80
Steelway, Ltd. 31
Sterling Metals, Ltd. 127
Sterling-Safway 84
Strachan & Henshaw, Ltd. 61
Stream-Line Filters, Ltd. 131
Sturtevant Engineering Co., Ltd. 22
Sunbeam Anti-Corrosives, Ltd. 59
Sykes, W. E., Ltd. 104

T. & T. Works, Ltd. 90
Tangyes, Ltd. 109
Taylor & Hubbard, Ltd. 15
Taylor Stoker Co., Ltd. 33
Taylor Woodrow 14
Tecalemit, Ltd. 16-17
Teleboist, Ltd. 49
Thompson Bros. (Bilston), Ltd. 140
Thornycroft, J. I., & Co., Ltd. 119
Tilghman's, Ltd. 133
Tinsley, H., & Co., Ltd. 134
Turbine Furnace Co., Ltd. 54
Twiflex Couplings, Ltd. 18
Tyler, E. W., & Co., Ltd. 2

Vickers-Armstrongs, Ltd. 44

Ward, T. W., Ltd. 148
Weir, G. & J., Ltd. 60
Welch, J. A. (Plant & Vessel), Ltd. 53
Wellington Tube Works, Ltd. 52
Wellman Smith Owen Engineering Corpration, Ltd. 74
Welsh Metal Industries, Ltd. 91
Wheatley, Kirk, Price & Co. 149
Wicksteed, C., & Co., Ltd. 120
Wigglesworth, F., & Co., Ltd. 54



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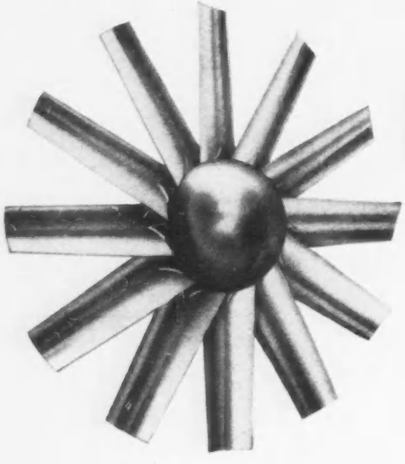

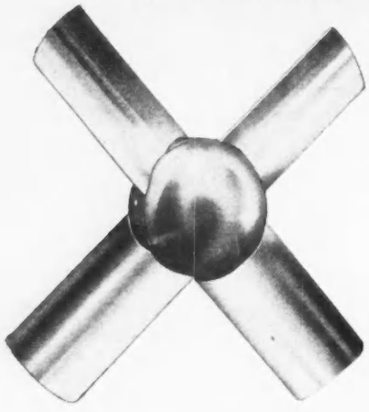

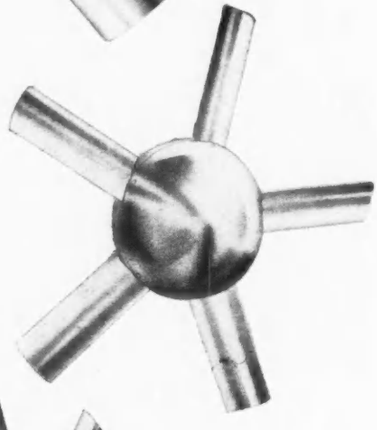

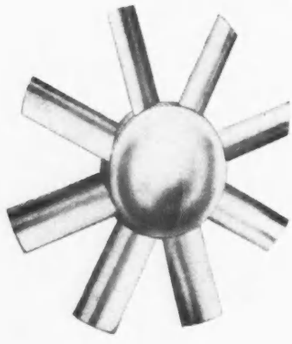

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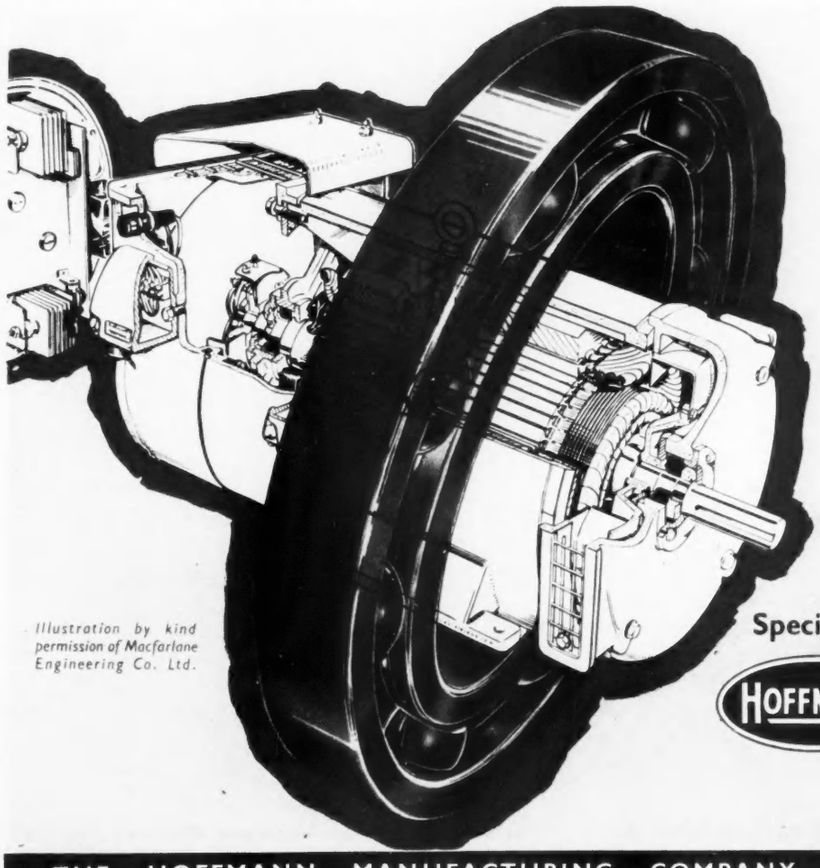

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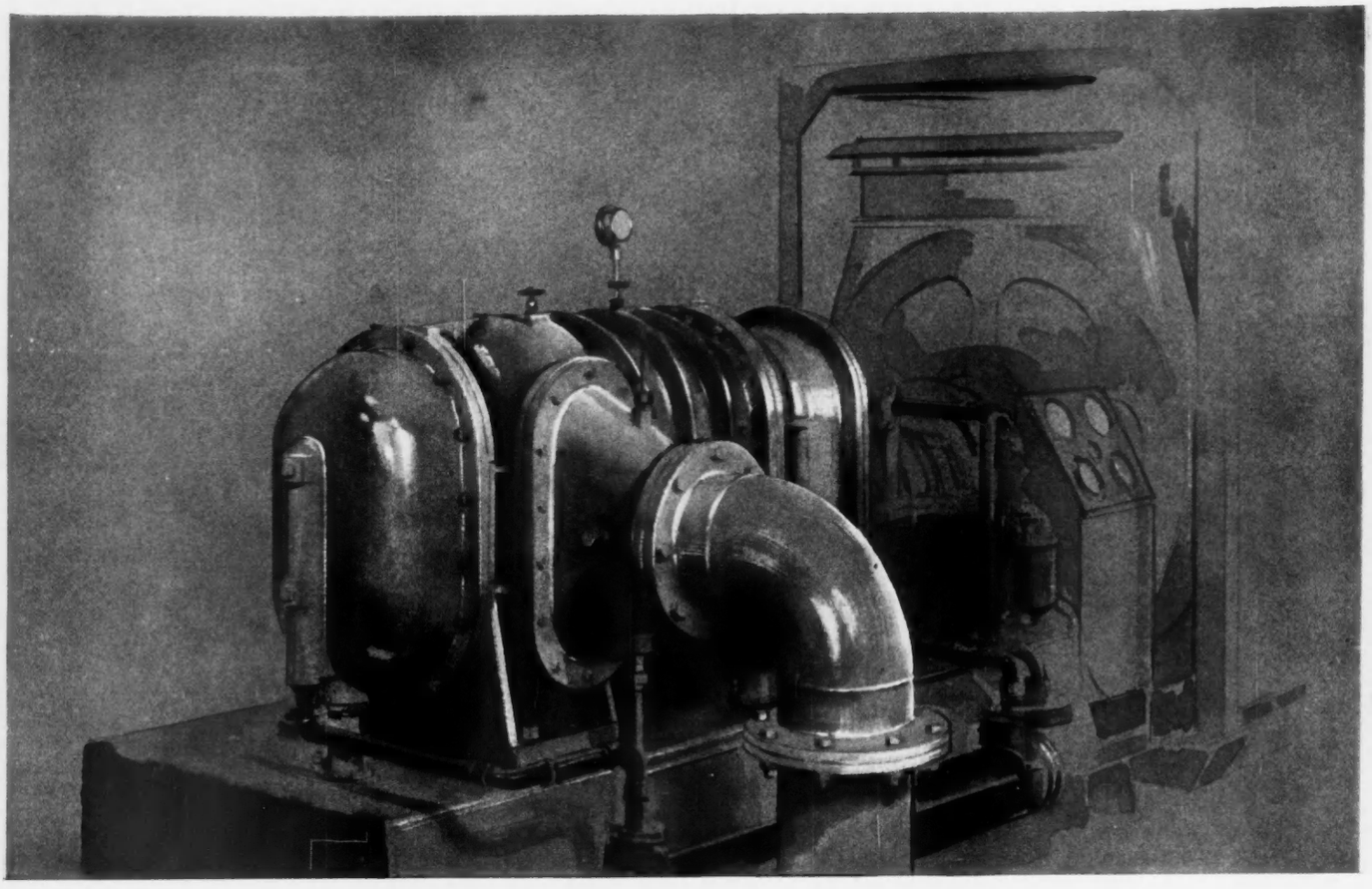

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